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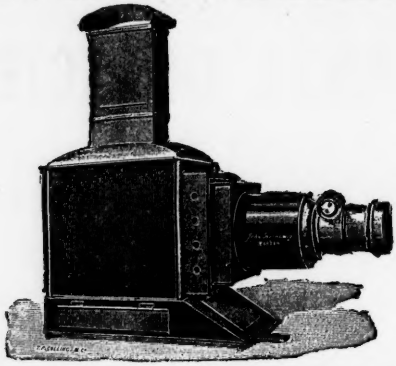

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THE

JOURNAL OF SCIENCE.

APRIL, 1881.

I. THE ORGANISATION OF MATTER.

By CHARLES MORRIS.

IN my article published in the "Journal of Science" (March, 1881) certain principles of aggregation of matter were applied to explain the original formation of the spheres. It was, at the same time, remarked that these principles applied to the formation of the minor elements of the spheres, and that the whole of concrete matter was probably organised under their influence. In the present article I design to apply the hypothesis to the formation of atoms and molecules.

If the matter of the spheres in their present state has only partially lost its original irregularity of motion, in the earlier nebulous state this irregularity was still more declared. After the great regular movements were produced—the cosmical motions of spheres as wholes—the same process continued to act upon their minor elements, to the production of smaller aggregations of accordant motions. In a vast mass of nebulous matter, moving in one direction, through a partial loss of the motion of its particles in the opposite direction, we can imagine its minor portions as gaining accordant motions, and separating from each other, in the same mode as the mass as a whole separated from similar masses of nebular substance. These minor portions would attract accordant motions and repel discordant, precisely as the mass as a whole had done. Thus small masses would gather out of the material of the large mass, some of them attractive, others repulsive, to each other, according to their directions of individual motion. Each, as a whole,

must have moved through space in the common direction of motion of the general mass, but its remaining motive vigour may also have become partly accordant, yielding it individual mass motion of its own, in some special direction. The individual motions of the minutest elements of the nebula would thus, through partial loss of motion in certain directions, become combined motions of minor aggregations of these elements in the opposite directions. But the direction of motion in these small masses would be subject to frequent changes through impact with other like masses.

It may be well here to consider an essential distinction between the results of impact and directive energy. An axiomatic phrase will indicate this distinction. Impact is centrifugal in its influence, attraction is centripetal. It may further be premised that impact is instantaneous, attraction and repulsion are gradual; impact yields straight lines and fixed speed of motion, attraction and repulsion yield curved lines or varying speed; impact acts immediately and through contact, attraction and repulsion act persistently, and from a distance.

Did impact exist alone all force would be centrifugal; there could be no organisation, and heterogeneous matter would perhaps tend to become homogeneous. It certainly could not tend to greater heterogeneity. All organisation results from the action of directive force, and the production of accordance between the motions of particles, under its influence. Attraction produces not a single initial change of direction and speed,—like impact,—but a continued series of such changes, and causes uniform motion in straight lines either to become motion in curved lines, or to accelerate or diminish in speed, according to the direction from which the force acts. This is the first specialisation of motion. It acts to reduce the amount of centrifugal energy, by bringing motions into parallel relations, and thus reducing the frequency of impact. Similar effects are produced by repulsion, but they differ from those of attraction by being gradually diminishing instead of gradually increasing effects.

The second specialisation of motion is produced when from the open curve proceeds the closed curve, motion in straight lines having thus changed into motion around a centre of attraction. In this condition of motion its centrifugal energy vanishes; all its force has become centripetal. And such a condition is essentially a persistent one. The centre of attraction around which the motions rotate owes its vigour to these motions, and thus must retain them in

persistent allegiance. Should the earth come into contact with any exterior body the impacting energy would be only that of its motion through space, not that of its rotation on its axis.

And another important question arises here. This is the question of the origin of the rotatory motion. Is it a transformation of the mass motion through space, or has it some other source? If the former, the particles must cease to move through space without a transfer of their motion of translation to any other substance. Motion in one direction would change of itself into motion in two opposite directions. Yet such a result is impossible. If the motions of the universe are accurately balanced in direction, no substance can lose its motion through space except by transferring it to some other substance. This is a fundamental principle of physics.

In a motion of rotation there is equal movement in even two opposite directions. For the location of the centre of gravity of a mass depends on there being the same quantity of momentum on every side of it. Therefore, if it were possible that the quantity of momentum in any direction could be reduced, the centre of attraction would necessarily shift its position so as to restore the balance. But such a balance, once existing, could never be lost, since the energy of one hemisphere must forcibly compel an equal energy in the opposite hemisphere.

Such a balance of motion in all opposite directions existed in every original mass ere rotation commenced, being what we know as heat vibration. Unless in the improbable contingency of the direct motion of the mass embracing all its energies, through the loss of all reverse motion, some fraction of this energy must exist as heat motion. And this heat energy must be of equal vigour in every direction; for if it were in excess in any direction, this excess would become new mass motion, either of the whole or a separated portion of the mass, or else would be lost as exterior impact, and leave the remaining motions in exact balance. The particles of the mass must therefore, in their individual motions, possess an equal vigour in every direction. But for rotation to arise something more than this individual balance is requisite.

In any mass of matter possessing an excess of direct over reverse motions, and therefore an excess of attraction over repulsion, this attraction, exerted between all the particles of the mass, necessarily generalises, and becomes in effect a single attraction exerted from the axis of movement of the

mass, its greatest vigour being at the centre of this axis, or the general centre of all the accordant momentums of the particles, and of the individual attractions of the atoms, if the mass is composed of atoms.

But any motion towards such a centre tends to vibrate through it; any motion transverse to it tends to change from a straight to a curved line, this curve arching inward if the motion be attractive, outward if it be repulsive. Thus around the centre of attraction of such a moving mass all accordant motions would bend into curved lines, the whole mass tending to rotate around its general centre of attraction.* But if its substance was perfectly homogeneous in condition this tendency would be equal in all accordant directions, and no rotation could result, the resisting impacts being exactly balanced. But if—as most probable—it was heterogeneous, the impacts would cease to be equal. There might readily occur an excess of motion in one direction near the centre, the point of strongest attraction. Such a motion would have an advantage over all more distant opposite motions. Its tendency would be to repel the reverse motions, and to move around the centre with a radius depending upon the degree of curvation. There would be a new series of accordant motions, yielding a new attractive energy upon accordant, and repulsive energy upon discordant motions. The original sorting out of directions of motion, under the influence of the motion of the mass through space, would be followed by a new sorting process under the influence of rotation of the internal portion of the mass around its centre. The central motion thus inaugurated must gradually extend its influence outward through the mass.

This new series of parallel motions set up in the mass would not necessarily be around the original axis of mass motion, but might be around a new axis of rotation, at some angle of accordance with the direction of mass motion. In such a process of formation the opposite axes of curvilinear motion must move reversely to each other, and therefore repel. Thus the circles of motion would tend to expand, the centrifugal energy of rotation being aided by

* Such curved lines of motion arising in one hemisphere of a globe are not produced by an attraction actually residing at the centre, but by the attractions of the opposite hemisphere. But these attractions are mutual, and their results must be equally balanced. The variation from a straight line of motion in any particle must be met by an equal opposite variation in some other particle or particles. No particle is fixed and incapable of variation in direction, and therefore the fixed balance in opposite directions of motion cannot be disturbed by any such mutual exercise of attraction.

this influence. This centrifugal energy might be such as to give the globe a discoid shape, or even, in the case of small masses of matter, to open it out into an annular ring, all the matter being repelled from the centre. The centrifugal energy would necessarily limit the size of the aggregation. Its attractive vigour would, of course, depend upon its quantity of parallel motion. But the force of attraction regularly decreases, and that of centrifugal energy regularly increases outwardly, so that at a fixed limit of distance the attraction would cease to control the momentum, and the possible size of the minor aggregations of matter be thus exactly fixed.

Such a minute aggregate of matter, locking up within its mass a certain quantity of momentum, would constitute an indestructible unit, the primary atom. The loss of any portion of its material, through impact, might readily be replaced through its attractive influence over the accordant motions of the surrounding ether, and thus its continued integrity be assured.

The attractive energy of such atoms must act outwardly as well as inwardly. But it would no longer be confined to its simple primary relations. There being a specialisation of direction in the motions of the atom, there would be a specialisation in its attractions and repulsions. The secondary aggregation into chemical units might possibly result from the direct coherence of two or more atoms into one mass, each retaining its original centripetal centre. And such coherent masses, acting as units, might unite again into still more complex masses, this process or combination continuing until not only the most intricate chemical elements, but the most complex molecules were formed.

The original atoms would be all similar, or would consist of a limited number of diverse kinds, each kind arising from a fixed decrease of temperature in a homogeneous portion of the ether. The complex atoms might vary in the number of their included simple atoms, the variation increasing as these secondary atoms became units in still more complex aggregations. At every step upwards the number of possible molecules would increase, this number becoming very great in the chemistry of the organic world.

In this process, however, the specialisation of motive conditions must rapidly increase, the original general attraction becoming more and more selective in character as the intricacy of motive relations become more declared. The whole tendency in this continued aggregation of ether must be to the production of harmonious relations of motion, a reduction

of centrifugal impact, and a loss of repulsive energy as motions become parallel and attractive.

Yet even in the most condensed spheres of space a large quantity of centrifugal force continues to exist, resulting from the original mass motions of atoms, and constituting the individual or the temperature motions of chemical molecules. This individual energy is most free and declared in the gaseous form of matter. In the gas harmony of motion is confined to the interior and the cosmical relations of the molecules. In their heat motions, as unit masses, they retain the individuality and irregularity of motion of the original ether. This energy is centrifugal. It yields impact force through their incessant collisions, by which they are driven back in straight lines in every conceivable direction.

The molecules of the atmospheres of the planets are only partly free in their motions. They must conform to all the regular motions of the planet. Their irregular motions are only the excess of motive force over these regular motions. They are also subject to the condensing force of inward attraction and outward pressure, thus increasing, through contiguity, the attractive energy of the particles of the gas upon each other. Thus the same influence is brought into action that acted upon the original ether. Attractive force tends to produce curved lines of motion in the gas. A loss of temperature, as before, decreases the centrifugal energy and increases the centripetal, until, finally, the curves become closed, and a new aggregation of matter results. The centrifugal heat vigour of the gas becomes centripetal, motion in straight lines becomes motion around centres of attraction, and the liquid form of matter replaces the gaseous. A new specialisation of matter has taken place, and the centrifugal energy of nature is still further replaced by the centripetal, through the increased harmony in motive direction. The free motions of the gas particles have become converted into the normal organising motions of the liquid.

But the impacting energy of gaseous molecules is also reduced by attraction in another mode. We have so far considered the attracting energies as acting from one side only. In irregular masses it thus acts from the side of greatest condensation. In regular masses it would act equally from both sides. The tendency there would not be to produce curved lines of motion, but to accelerate the motion of approaching, to diminish that of receding, particles. In short, vibration would result. Such vibratory motions are probably of frequent occurrence in gases, and

reduce to some extent the number of centrifugal impacts. In another form of matter, the solid, they constitute the regular condition of temperature energy. In this form the attractive energy has become so greatly enhanced through contiguity of particles, and the impact energy so greatly reduced, that vibration has become the normal mode of temperature motion, and impact has become abnormal, instead of normal as in gases. There is no tendency here to the curvilinear mode of motion. The aggregation in solids has become so regular that attractive vigour acts equally from all sides, its natural result, therefore, being the vibration. If a gas could retain a homogeneous state of condensation while continuing to lose temperature energy, it might at once pass into the solid state without entering the intermediate liquid condition. It would simply need that the attractive energy should become stronger than the temperature energy for the motion in straight lines to become vibrating motion, and thus for the solid state to be assumed.

But gases are ordinarily heterogeneous in aggregation. Attraction acts more vigorously from one side than from the other. Curved motions result. The closed curve finally arises, and the liquid form is produced. From this the solid is more easily constituted. The motions in liquids are far more regular than in gases. A much greater homogeneity of aggregation exists. The curve, affected by equal forces from both directions, tends to become the vibration, and the solid thus readily arises from the liquid.

The gas, therefore, may be reduced to the liquid or the solid state by attraction overcoming momentum in two diverse modes. Attraction in a regular mass of particles tends to produce vibration; in an irregular mass it tends to produce rotation. Yet it does not follow that these two results arrive at the same degree of reduction of temperature. The vibrating particles constantly increase their distance from the attracting centre, the vigour of this attraction thus rapidly decreasing. They also enter new fields of attraction which strengthen their motive vigour. Thus the lateral attractions which converge upon the centre of motion of the particle must be powerful enough to bring it to rest ere it can feel the full vigour of a new attractive field. In curved motion, on the contrary, the particle is held at a regular distance from the centre of attraction. This force does not diminish through increasing distance, nor is it overcome, to the same extent, by the influence of more distant centres. Thus a less degree of energy is necessary to produce the closed curve than is required to yield the

vibration as a normal condition, and matter enters the liquid state at a considerably less reduction of temperature than that required to produce the solid state.

Throughout the whole process one general principle holds good—a constant tendency to homogeneity. Motion becomes more and more regular from the ether to the solid. It first becomes regular and centripetal in its energies in the atom. Then the irregular mass motions of atoms become reduced by their aggregation into molecules. The irregular motions of gas molecules become partly regular in the liquid form, and wholly so in the solid; for it is probable that in the interior of a crystal attraction is the only mode of energy, the vibratory swing of the particles being synchronous, so that no contact takes place between them. In such regular solids, therefore, it is probable that the molecules are arranged with complete regularity, that impact force occurs only at their point of contact with exterior substances, and that in their interior conditions only the centripetal energy of attraction is exercised.

In the original formation of the spheres a complete homogeneity of the mass might have prevented the liquid condition of rotation being assumed, the mass gradually condensing and solidifying, without assuming rotation either as a whole or in its minor portions. But such homogeneity is practically impossible in any large aggregation, and the liquid phase of matter, therefore, always precedes the solid.

On conversion of the gas into the liquid form a certain result arises as a necessary consequence of the changed relations of the molecules. In the gas they possess a vigorous centrifugal energy. Their motive vigour is constantly exercised in beating back the surrounding molecules, so that each retains for itself a considerable free field of action. As pressure increases and its field of action diminishes, its number of impacts increases in accordance, so that its resistance remains in equilibrium with the pressure. But on reduction to the liquid state this centrifugal energy is suddenly converted into centripetal. The resistance is greatly reduced, while the pressure remains the same. Thus the liquid mass becomes greatly condensed, the particles being driven inwards towards the centre around which they rotate. Yet in the liquid we find a condition that does not exist in either the gas or the solid. In the former, increased pressure condenses the mass by reducing the field of movement of the molecules and increasing their number of impacts. In the latter it condenses the mass by raising the pitch of vibration, or causing the molecules to move more

rapidly in a contracted space. In the liquid neither of these results can occur. The diameter of the circle of motion is governed by the relations of the rotating speed to the central energy, and cannot be changed by any exterior force. It resists pressure, therefore, with great vigour. While the particles of the liquid readily change places, the liquid as a whole refuses to yield to pressure, the centrifugal energy of its innumerable circles of motion not admitting of being packed into smaller spaces, as in the gas and the solid. It is the rigidly elastic phase of motion.

There are certain relations existing between the three forms of matter which require to be now considered. We refer to what has been known as latent heat, the disappearance of heat energy when solids become liquids, or liquids become gases, and its reappearance in the reverse cases. This seeming disappearance and reappearance are a necessary result of the inter-relations of the three forms of matter.

If we consider a molecule of a solid as coming into contact with a molecule of a liquid, at the same temperature, is it probable that they would have the same impact influence upon each other? Suppose, for illustration, we should strike with a pointed hammer upon a mass of liquid of the same weight, stopping the blow at the instant that the point of the hammer meets the surface of the liquid. Evidently there will be a much greater disturbance in the liquid than in the solid. It is a simple question of resistances. All the material of the hammer resists on the one part, while only a small portion of the liquid resists on the other. Thus the slight vibration which runs through the substance of the solid is paralleled by a considerable disturbance of the substance of the liquid.

This illustration applies exactly to the contact of single molecules. Each molecule of the solid is held vigorously in place by the surrounding attractions. The molecule of the liquid is held more feebly in place. The whole substance of the solid aids vigorously in the resistance to impact, while a much slighter resistance exists in the liquid. Thus the solid molecule strikes the liquid with the force of a minute hammer with a molecular point, while the liquid molecule strikes back with little more than its individual force. Therefore every stroke of molecule on molecule has the real effect of a considerable number of solid molecules striking a much less number of liquid. How can this advantage in the solid be obviated? Evidently if the liquid molecules is not sufficiently aided in its resistance by its fellows, it must possess

an extra vigour of individual resistance. It must be strengthened in itself to meet the combined assault upon it. It must, in short, possess much greater momentum than the solid molecule to give it an equal resisting energy.

This extra momentum is extra temperature energy, which is needed to place solids and liquids in equilibrium, as regards their radiant force; and it is this which constitutes the so-called latent heat of liquids. Similar temperatures in liquids and solids really require a much greater motive vigour in the slightly resisting liquid particles than in the rigidly linked solid particles, and this extra motive vigour must be absorbed before they can become equal in centrifugal energy.

The same principle holds good between liquids and gases. In the latter the resistance is still more reduced. The molecule is largely individual in its energies, being but slightly aided by its attractive relations with surrounding molecules. Thus it again is at a disadvantage as compared with the liquid, and needs a much greater vigour of impact in itself to balance that portion of resisting or impacting vigour which the liquid molecule borrows from its neighbours.

In the reverse process the opposite result occurs. In the gas becoming the liquid it finds itself possessed of a great advantage in resisting vigour, and yields momentum to the slightly resisting gas until the latter gains equality of resistance by a great increase in the impact energy of its particles. A like result occurs in the change from liquid to solid.

This principle probably extends backward unto the simplest form of matter, every new integration from the original ether needing a smaller quantity of impact energy than is possessed by the more simple forms to put it into temperature equilibrium with them. The more individual the particle becomes the greater personal vigour it needs, its resistance to impact being less aided by the force of contiguous attractions.

There are other characteristics of matter which probably arise from the causes above mentioned. As we have said, increased external pressure upon a solid may raise the pitch of vibration of its particles, by forcing them to move in a smaller space. Increased temperature may perhaps have a like effect. Expansion of the mass here causes increased pressure, and may thus produce a higher vibratory pitch, this rising until it becomes sufficiently high to yield the pulsations of radiant heat and light, through all their various grades of pitch.

But as the mass expands the rigidity of connection between its particles decreases. Thus the resistance of its particles to heat impact decreases. It has partly lost the combined energy of impact which it previously possessed, and needs greater individual momentum in its particles to enable them to resist an equal vigour of exterior impact. In other words, its capacity for heat increases as its temperature rises.

In liquids a similar condition exists. They, too, have their normal pitch of heat vibration, which rises as exterior pressure increases. They have also their combined resistance to heat impact, which decreases as expansion increases, their capacity for heat thus augmenting.

In gases these conditions are almost non-existent. The gas molecule is almost entirely free from coercion. Its field of movement may decrease or increase, but it continues to act almost entirely as an individual, and is little subject to the influences which liquid or solid molecules experience from their intimate relations of attraction with their fellows. The pitch of vibration of the gas particle is a resultant of its weight; those of the liquid and solid particles of their combined weight and tension.

If we consider the state of affairs existing in liquids we find a marked absence of rigidity. We may imagine the liquid to be made up of minute spheres of rotating particles, the exterior portions of which are divided in allegiance between two opposite centres of attraction. Such a freedom from special coherence of the exterior shells of such spheres must greatly reduce the frictional resistance between them, so that they may move upon each other with the greatest freedom. In the same manner the least disturbance of the liquid may cause a considerable transfer of allegiance in its particles, the material surrounding each centre of attraction being thus subject to frequent changes. Also any unoccupied space would speedily be filled by a new centre of attraction arising between the particles pressing into it. This constitution of a liquid mass is not apparent to us, from the minuteness of these spheres. But we perceive it in every instance where a water drop has an opportunity to assume its natural shape, it forming a globular mass around a centre of attraction, about which its particles are, very probably, in rapid rotation. Wherever a liquid has a fair opportunity to escape from certain opposing influences, and to display its normal tendencies, the globular shape immediately appears. Ordinarily the liquid has to contend with gravity and atmospheric pressure, and frequently with cohesive

attraction, so that it is reduced to a level surface. Yet the minor aggregations of which it is composed escape these influences, and very likely are globular in form. The liquid, in fact, differs from the gas in that it has lost its impact resistance to pressure, and has become an aggregation of molecules similar to the aggregation of ethereal particles in the atom. Having no mass motion, and therefore no impact resistance, the rotating liquid globes are in contact, their only resistance to pressure being that of elasticity.

As the complexity of molecules increases their attractive vigour diminishes. They cease to combine into the rigid solid, but display in their combinations the globular aggregation of the liquid, forming what is known as the colloid state of matter. These colloid globes are more coherent than ordinary liquid globes, and retain their individuality, instead of readily fusing as liquids ordinarily do. But an incomplete fusion often appears between them, and combines them into coherent masses. Usually, in their individual form, they are not subject to the influences affecting the drop of liquid, since they exist as single masses in liquids, where they are not exposed to pressure. But certain influences, possibly of an attractive or repulsive character, act to overcome the feeble centripetal energy of the colloid masses, and to change their globular into an irregular form. These yield a result not unlike that which pressure and cohesion produce on the liquid drop. The main difference is that the feebler centripetal energy of the liquid drop causes it to readily break up into several individuals, while the colloid is more persistent in its aggregation. Yet new centres of force often arise in its irregular protrusions, or appear in its midst when it becomes of considerable size. In short, it displays curious analogies to the action of liquid drops. These phenomena, however, take place under influences different from those which produce like changes in liquids, and a further consideration of them would lead us from physical into biological science.

One further deduction seems to arise from our premises. Let us define the molecule. We may view it as a single centripetally organised mass of matter, composing a natural unit or individual, and whatever answers this definition should rightfully be classed as a molecular aggregate. The simple atom is thus a molecule of the original ether. From this atom more complex molecules arise, until we reach the most intricate organic molecule. But higher definite aggregations of matter answer to the same definition. They are single centripetal aggregations of minor elements. Such is

the drop of water. It is a collection around a centre of attraction of all the substance which that attraction is capable of condensing. The same thing may be said of a crystal. It is a centripetal aggregation assuming a definite shape around a centre of formation. We may even say the same of a colloid mass, a single animal cell, or a single-celled animal. It is a centripetal aggregation of smaller molecules around a centre of attraction, precisely as the chemical molecules are aggregations of atoms definitely arranged about a centripetal attraction.

We may even pursue this thought further. What is a many-celled animal but an aggregation of colloid molecules around a centre of organisation, a centripetal force which controls and arranges them into a definite and self-limited mass. Thus we perceive the conditions of organisation of the smallest aggregates of matter reappearing, in an advanced stage of development, in the highest aggregates. Each is a unit of organisation around a centre of force, and is limited in its dimensions by the vigour of this force. The principle that governs the simplest aggregate of matter thus governs the most complex. Each self-limited aggregation around a centre of force, from the atom to the man, is a unit of nature, analogous in constitution to all the other units.

These units resemble each other in another particular. They are all polar in force. The atom, as we have argued, is a rotating sphere or ring of matter, with its axis of rotation and its poles, these possibly displaying the magnetic energy. Every molecule has probably one or more axes. Every rotating liquid sphere has its axis and its poles. A complex polar organisation exists in crystals. Finally, a polar organisation is observable in single-celled animals and plants, and undoubtedly exists in the highest organisms.

The tendency of every colloid mass, whether simple or compound, is to become globules. But its material is influenced by exterior forces as well as by the centripetal force. It therefore becomes variously irregular in response to these exterior relations. Such irregularities become permanent since they arise from permanent conditions of exterior force. The plant, for instance, tends to the axial form, since extension into earth and air is necessary to its existence in any advanced condition. There are undoubtedly attractive influences which act to produce this form. The animal tends to the globular form. Its attractions are central, not axial, as in the plant. Its divergences from the globe, therefore, do not arise from attraction, but from pressure, and from the necessity of conformity to other exterior conditions. In the

plant the energy of the poles predominates. In the animal the energy of the centre is most vigorous. The attractions of the one are axial, those of the other central. If only attraction acted upon them the one would be a cylinder, the other a globe. But there are numerous other forces, which produce various divergences from their typical forms.

The foregoing considerations lead us to one general conclusion as to the organisation of matter, namely, that the three visible states of matter—the solid, the liquid, and the gas—are the only states, the action of force tending to the necessary production of one or the other of these states. The gaseous is the disintegrated state. It is the condition of individuality of concrete units. These, in their internal organisation, may possess the liquid or the solid constitution. Externally they have a free field of movement, and vigorous mass motion enabling them to occupy the field. The particles of the free matter of space, and the molecules of the atmospheres of the suns and planets, are in this condition, subject to attraction, but not definitely controlled by it, the only effective controlling influence upon their motion being that of impact.

These units, in their internal organisation, may be in the liquid state of aggregation, though it is more probable that the chemical molecules assume the solid state. The spheres as wholes also display the liquid phase of aggregation, that of rotation about an axis of attraction, with a condensation of their material around the centre of this axis. Solar systems, as units, are also in the liquid state internally, that of rotation around a centre. Each planet represents an annular ring rotating around a centre. In most of the planets this ring has broken up, and its material gathered into one mass. This breaking up and re-aggregation is only partly accomplished in the case of the planetary ring between Mars and Jupiter. In the inner satellites of Saturn the rings remain complete, yielding a condition possibly similar to that which may exist in the organisation of the primary atoms of matter.

But if we consider the solar systems as units in their exterior relations, it is possible that we may have an instance of the gaseous organisation. For, as argued in my article on "The Evolution of the Spheres," they may possess an inter-relation of organisation, but may exist as free moving individuals, precisely analogous to the unit components of a gas. Like the latter, they are subject to attractive and repulsive agencies, dependent upon the directions of their motions. But these are perhaps not sufficiently vigorous to

force them into closed circles of rotation, so that impact may act as one of the controlling agencies upon their direction of motion. In the article mentioned the rarefying effect of such impact was considered. A similar influence, in a minor degree, may affect atoms and molecules when they come into collision, or when they feel the influence of mutual repulsion, their motion through space becoming temporarily converted into internal vibrations of their component particles, or a widening of their radius of internal motion.

The liquid organisation being thus possibly a rotation about an axis of attraction, the question arises—What is the exact condition of the solid organisation? We have argued that solids might arise directly from gases, if these latter were perfectly homogeneous. Such a homogeneous condition may exist in liquids. Their particles having a fixed vigour of movement, the centripetal energy arising from this momentum may be equal at every centre of organisation, so that all of the minute globes may be of one fixed size. In such a case the liquid would be homogeneous, and every particle between and equally distant from the centres of two such globes would necessarily vibrate in a straight line, as though it were attached to the middle of an elastic cord joining these centres. If then, through loss of heat, these centres closely approached, there might in this way be an insensible change from the liquid to the solid state.

But in the solid another mode of action of attractive energy is at work. Despite the fact that the attractions of a mass of particles converge and act from a general centre, the individual attraction between contiguous particles persists. While aiding the general force, it continues to act as an individual force. In the formation of a globe of liquid matter it is not alone the circling motions of the molecules which yield the attraction. A more vigorous force comes from the interior motions of the molecules. These, being in accordant directions, converge, not to an axis, but to a centre of attraction, and are probably far more vigorous than those of the circles of rotating motion. These latter possess a degree of centrifugal force, while the attractions of the individual molecules are wholly centripetal.

But there is a degree of opposition between the local and the general exercise of molecular attraction. Every molecule is attracted in opposite directions by those immediately surrounding it, and tends to vibrate between these opposite attractions. There is thus a struggle between the local and the general attractions. In response to the one, the molecule seeks to rotate; in response to the other, to vibrate.

The vibrating energy has the advantage, in the case above referred to, of particles intermediate between two centres of attraction. It also grows rapidly in vigour as condensation ensues through loss of temperature, attraction increasing in the rapid ratio of the reverse square of distance. Thus a certain degree of propinquity may give the local energy a greater force than that of the combined central energy. The tendency to vibrate between contiguous particles becomes in excess of the tendency to rotate around a general centre of force. Yet the mass is organised in the spherical mode of motion, and a considerable excess of the opposite tendency is necessary to overcome this organisation, unless the liquid be disturbed. If it be disturbed the particles at once break loose from their allegiance to the centre, and begin to vibrate in allegiance to the local energies. The liquid becomes the solid.

But the attractions of molecules are not equal in all directions. If they are rigid, or solid aggregations of atoms, their attractive energy must be strongest in the direction of greatest accordance of motion, weakest in the direction of least accordance. Thus the molecule which vibrates under the influence of several surrounding molecules may feel attractions of diverse vigour in different directions, and may thus be able to move through a wider field in some directions than in others. The molecules have a double influence upon each other. They force each other to assume similar polar directions, precisely as a mass of minute magnets might do. Their poles being thus all in one direction, their greatest vigour of attraction would be in one fixed direction, their least in another. The field occupied by the vibrating molecule must be governed by the condition of the internal motions of the molecules, and the consequent vigour of their attractions in various directions. It might be equal in every direction, or it might have three or more poles of force differing in vigour. And every molecule, while under the influence of a series of surrounding molecules, would form a member of several new series, influencing the motion of other molecules. Thus each molecule would be surrounded by others occupying the angles of some geometrical figure, and its resultant field of action must be an angular instead of a curvilinear space. In short, from such a mode of aggregation, the angular formation of the crystal must result, its shape being fixed for every kind of molecules, since each kind has its peculiar relations of attractive energy.

In very complex molecules, of weak attractive adhesion, the central may again overcome the local energies. These

molecules may have the liquid instead of the crystalline condition. Their mass formations may thus take place in the liquid mode, yielding the colloid, which replaces the crystal in the aggregations of such complex molecules.

II. THE FUTURE "MARTYRDOM OF SCIENCE."

By Frank Fernseed.

IT is commonly, and perhaps too readily, taken for granted that the position of Science and of her followers will be higher and safer in the future than it has been in the past. Those influences and organisations which have oppressed her are, it is supposed, decaying, whilst those which have been her fellow-sufferers, and which have applauded her revelations, are rising into power in their stead.

The other day I saw on a posting-bill these strange words:—"Christianity at the Bar of Science!" "How?" I said, "are Galileo and Bruno about to sit in judgment upon the cardinals, thus reproducing an old error in an inverted form?" But on what authority or on what grounds is it assumed that Science will, in days to come, possess any jurisdiction, legitimate or illegitimate?

In an article which appeared in these pages in March, 1880, it was shown that the former persecutions of discoverers have sprung not alone from clerical ill-will, and a prediction is even hazarded that in future the work once carried on by Caccini and Scioppius will be taken up by very different hands. In other words, scientific research will be denounced and opposed by the leaders of "advanced thought," theological,—anti-theological rather,—philanthropic, social, and political!

This foreboding may at first sight appear paradoxical, and even absurd. Does not the "advanced thought" in question loudly proclaim universal toleration, right of private judgment, liberty of speech? Doubtless; in the days of the first French Revolution it did likewise, till all these brave words ripened into the utterance "The Republic has no need of chemists," and till the achievements and the

reputation of Lavoisier, of Bailley, and Condorcet had no power to save them from looking through the "national window." How do men, certainly not under the sway of what is commonly called religious bigotry, speak even now of Science? "The time is near at hand," says the President of a provincial Literary and Philosophical Society, "if we may judge our age by its tendencies, when the pursuit of Science will have to justify itself anew to the reason of mankind!" According to this authority, then, Science is to take the place not of a free agent, much less that of a judge, but of a prisoner. Her place is to be not on the bench, but, as of old, at the bar.

In a work lately reviewed in the "Journal of Science" (November, 1880, p. 725) we are told by a writer utterly free from any theological bias that "the life that is wholly given over to such pursuits (*i.e.*, research) is a misspent one, and is, as an example, positively injurious to society." What more was ever said by the Holy Inquisition? It is generally considered to be within the competence, and even the duty, of governments to repress whatsoever is "injurious to society," and if, therefore, men holding views similar to those of the writer just quoted should ever come into power, may we not expect interference with research?

Mr. E. R. Russell, in an essay on Trevelyan's "Life of Macaulay," about two years ago, declared "He (*i.e.*, Macaulay) never thought it worth while to quit more attractive studies for the blind and groping physicism which now almost monopolises the name of Science. Whatever good it may have done in other directions, physical science has of late discouraged and debilitated moral and historical inquiry, which is of much more value to the world." Here, therefore, we again find the charge that Science is in some respects hurtful to Society. Are, then, proposals for its repression likely to be very far distant? An eminent author who has recently passed away from among us asked scornfully "whether the heavens were made for Herschell telescopes to shoot Science at?" Even Comte, in many passages of the "Philosophie Positive" (*e.g.*, iv., p. 605), speaks with very little respect, or even toleration, for the scientific specialist. Nor must we here lose sight of the anti-vivisection agitation, a movement largely supported by our "advanced" historians, novelists, and free-thinking writers, and which has been carried to the length of the destruction of the Physiological Institute of the University of Leipzig. Thus we see that varied voices are now raised against Science, certainly not in obedience to any theological or religious

inspiration. Nay, she is even denounced as willing to enter into a concordat with Religion!

Let us look at the subject from another side. What first led the fathers of the Church to turn an unfavourable eye upon natural science? They considered themselves—whether rightly or wrongly is not here the question—entitled to the spiritual guidance of mankind. They were, in their own undeniably sincere belief, the depositories, guardians, and promulgators of truths of transcendent importance to the destinies of mankind.* We can well understand how, filled with such notions, they must regard the teachers of any other doctrines with mistrust and jealousy. However true might be the tenets of the "philosophers," they were looked on by the Church as mere trifling, calculated at the best to withdraw men's minds from their eternal interests. Even, therefore, where no positive contradiction could be traced between Science and Revelation, a feud was inevitable, in which the more powerful party considered itself to be merely suppressing something "injurious to society."

If we now contrast the position of the early Church with that of our "advanced thinkers" of the present day, we shall discern a considerable degree of analogy. The same advanced thinkers—rightly or wrongly it here matters not—conceive that they are the custodians and champions of certain principles for which they wish at all hazards to secure predominance. They have "reforms," possibly revolutions, to effect, and they are angry at every one who refuses to give them his attention,—angrier still and jealous of every man who seeks to engage the public mind with other, and in their opinion comparatively unimportant, subjects. Ebenezer Elliott, the "Corn-Law Rhymer," takes occasion to denounce bitterly the working-class naturalist, who spends his leisure in the woods, studying the habits of insects, instead of taking part in public meetings and reading political organs. The agitator of to-day, like the saint of old, brooks neutrality even less than opposition. Those who are not with him he thinks against him; those who will not be his brothers he must kill! All the time, energy, attention, wealth, expended in research into the secrets of Nature, he views as not merely wasted, but as something stolen from his "movements." Hence he has the same general diffused ill-will to Science which was felt by the Church in the earlier part of her career.

* The reader may consult WHEWELL, Philosophy of the Inductive Sciences, ii., 151 and 153, and History of the Inductive Sciences, i., 267 and 423; ENNEMOSER, History of Magic, i., 355; QUINET, Ultramontanism, 52, 58, 71.

Again, the two powers which were brought in presence of each other in the first centuries of Christianity regarded the world from respectively different points of view. The "philosophers" aimed at tracing facts to physical causes, and, in as far as they had succeeded in arriving at definite knowledge, they saw in all phenomena the working of unvarying law. The fathers of the Church, on the contrary, sought everywhere for moral causes. In all that is they saw or supposed to see personality, will, purpose, arbitrary and even inconsequent. Whether these two opposite views might not ultimately admit of reconciliation neither saint nor sage cared heedfully to ask, and the elements of a "very pretty quarrel" were therefore near at hand. This fundamental opposition between the philosophic and the religious conceptions of the universe has often been set forth, and is noted here solely by reason of its parallelism with another antagonism which is springing up in our days. Till very lately none of the branches of natural science, nor, it might be said, the general spirit and method of science, seemed to approach the territory which the self-styled advanced thinkers in philanthropy, in social reform, and in statecraft claim as their own. Man, whether as an individual or as a member of a community, was openly, or at least tacitly, excluded from the "kingdom of Nature." The differences between man and man were, and still are, traced exclusively to education, to position in life, and to other outward post-natal circumstances, or else to the different action of the free-will of each individual. The distinctions between nations, with perhaps some little reference to the climate, the soil, the productions, and the geographical position of their countries —conceded very grudgingly—were and still are accounted for by laws and institutions. Society was considered as a something modifiable almost at will by the educator and the statesman. Till lately these views reigned uncontested; but modern science, especially since the great reform in Natural History, has restored man to his place in the "kingdom of Nature," just as the astronomical reform of Galileo and his contemporaries "restored earth to her place in the heavens." Anthropology, psychology are now brought into intimate relations with biology, and sociology itself—if such a discipline can really be constituted—will be studied with reference to the organisations existing among the lower animals. Is it probable that such a change in point of view can fail to lead to inferences novel, and therefore unwelcome? Is it likely that the moralists, the historians, the orators, and the metaphysicians will listen patiently to so new and strange a

voice? Will not they take umbrage at the very same reference to physical causes which so offended the fathers of the Church in the first centuries of our era?

Thus I come to the third and final point—the actual conflict of doctrines. Reverting for a single illustration to the old feud between Science and the Church, it will not be forgotten that the "philosophers" held the earth to be one out of a number of kindred worlds revolving around a mighty luminary, the sun, and as being a mere speck in a universe practically infinite. The Church, on the other hand, viewed our globe as the largest and the sole inhabited and habitable body in creation,—as fixed immovably in the centre, whilst the sun and stars revolved around her to give her light and to mark out the seasons. It is not for me to say whether these views are really taught by the Scriptures or not. What concerns us is merely that the Church considered the geocentric theory of the universe as part and parcel of the Christian revelation, and pronounced every antagonistic teaching heretical. Such being the case, we look round and find contradictions equally flat between the teachings of modern Science and the creed of our "advanced thinkers."

It is well known that brutes transmit to their offspring not merely what are called generic and specific characters, but those attributes which distinguish individuals of any given species from each other. Among those domestic animals which have been most carefully observed, we find that not merely colour, size, peculiarities of make, but speed, endurance, and temper go from sire or dam to their descendants. So well is this known that to expect anything else would be looked on as highly ridiculous. Take the colt of a pair of ordinary hacks—would any amount of training ensure it a "place" at the Derby or the St. Leger? The horses which win cups, or those which bear heavy riders across country in the hunting-field or in battle, are members of an equine aristocracy.

We have been much more slow to perceive that the same law applies to our own species. But, thanks to the careful and systematic researches of Mr. Galton, the facts of human heredity are now placed upon a safe base. It is fully proved that stature, complexion, strength, longevity, tendency to certain diseases, eminent mental gifts, peculiarities of moral character, and even little oddities and eccentricities "run in families." The cavil that such resemblances are due to training, imitation, or post-natal circumstances whatever, is so abundantly refuted that it is no longer worth a

serious consideration. Just as there are family peculiarities reaching down through many generations, so there are in every moderately unmixed nation racial peculiarities which may be traced for centuries, which follow a people from barbarism to civilization, and which survive changes of law and government and all those varied agencies to which rhetoricians are fond of ascribing national character. What training or what institutions, for instance, would ever enable a normal Teuton to lie with the readiness, the skill, and the predilection of the normal Slav?

But this very law of heredity, tacitly admitted by every breeder or trainer of domestic animals, and proved as clearly as is any law of organic nature, is not merely denied by the "advanced thinkers," *i.e.*, Buckle, but excites a John Stuart Mill to something bordering upon fury. Why is this? If we examine the inferences which may possibly be drawn therefrom, we shall see that they, to appearance at least, clash with certain principles which the "advanced thinkers" uphold, and which they seek to embody in the form of laws and social arrangements. I hasten to say that I have no wish to decide whether this contradiction is real or only seeming, and whether the differences referred to may or may not be ultimately harmonized. One of these principles is "equality." "All men are born equal," says the Revolution, "and one man is as good as another." "All men are not born equal," replies biological science. It may, indeed, be urged that the equality contended for is merely one of social rights and privileges, and does not involve an equality of being. Is it always practicable to define these two kinds of equality so as to draw a definite line between them? And if our "advanced thinkers" claim for all men merely an equality of legal rights why are they so angry at the doctrine of heredity?

Again, it is contended by a certain school of writers and speakers, following more or less thoroughly in the footseps of Helvetius, that the difference between the genius, the man of mere average faculties, and the fool, is simply one of education. This dream was long ago condemned in the old adage "poeta nascitur, non fit." We now know that education and discipline at home and at school can do very great things with and for the average man, but can effect little for the highest and the lowest order of minds. The genius can dispense with it, and upon the dolt it is to a great extent thrown away. In virtue of the law of heredity science denies universal educability.

A third point of collision is the treatment of crime. If

there is any truth in the doctrine of heredity criminals reproduce criminals. Without wishing to deny that a normal man may, under the pressure of circumstances or from the influence of sudden temptation, commit some casual offence against property or even against the person, we must remember that the systematic habitual criminal, who formally prepares and equips himself for war against society, is the descendant of a line of similar characters who annoyed our forefathers, and that if permitted he will become the progenitor of a race of nuisances to scourge the public in times to come. What is the probability of reclaiming such a being? By what sign are we to know that he is reclaimed? If he is submissive in prison and listens decorously to the monitions of the chaplain is he not "simply biding his time?" Hence the doctrine of heredity involves corollaries little in favour of that indiscriminate leniency in the treatment of crime which has been substituted for an equally indiscriminate rigour, and which our humanitarians wish to extend even to the length of allowing the paltry fines for ruffianism—licences after the fact—to be paid for by instalments. Justice writing up over her doors "weekly payments taken! Thus we see that the law of heredity seems to clash with no fewer than three of the favourite dogmas of our social reformers as decidedly as did the Copernican astronomy with that geocentric system which the Church had taken under its protection. Is it likely that this collision will be unseen, or if seen that it will be accepted with indifference?

We may go further; one of the latest and most interesting results of scientific research, especially into living existence, is recalled to the mind by the much-ridiculed term differentiation. It has been found that in proportion as any being advances in development its former homogeneous structure becomes resolved into parts mutually unlike and subserving different offices and yet harmoniously linked together for the preservation of the whole. We see further that what is thus met with in the growth of the plant or animal from a seed or a germ to full maturity, is repeated in the growth of human society from savagery to civilization.

It may be asked how can this truth come in collision with the creeds of social reformers? In reply I point out that a distinction is now menaced which has become more marked as civilization advances and as the division of labour is felt to be a necessity. I refer of course to the so-called "woman's-rights movement, the

aim of which is substantially to identify the functions of the two sexes, or if possible even to reverse them.

Again, Science teaches us that the species is of more importance than the individual. She shows us that nature in seeking to advance the type sacrifices—if there is any truth in the doctrine of natural selection—millions of its components. She bids us mark how animals of varied grades can throw off a mutilated limb to preserve the body to which it belongs.

Yet our "advanced thinkers" seem to hold that the rights and interests, even the whims of the individual, however temporary, transcend the claims of the community. Nay, a heterodox and anti-vivisectionist writer has even stated, as the characteristic of his school, that it considers the claims of the individual as paramount.

We need scarcely seek for more instances to prove the position taken that certain scientific teachings do not accord with the principles of the "advanced" social thinkers. We see that just as in the old antagonism between Science and the Church there is here jealousy, a generally different point of view and specific doctrines hard—even if possible—to reconcile. Why should this discord be unattended with results similar to those recorded in the middle ages? I do not mean to say that men of science are in any danger of the scaffold or the stake, though they may, as in Leipzig, be exposed to popular violence. Modern persecution has other methods of crushing its victims.

III. THE PHOTOPHONE.

By J. Munro, C.E.

THE last five years have given to the world three extraordinary inventions, the telephone, the phonograph, and the microphone. They are all concerned with sound, and are in reality aids to our powers of hearing. The telephone enables us to hear sounds, especially the human voice, at a great distance; the phonograph permits us to record speech directly without the use of letters, and to reproduce the original words; and by the microphone we can magnify minute sonorous tremors till they come within the range of our hearing. Moreover, they are not only allied in

their uses but in their origin, for the phonograph was suggested by the telephone, and the microphone could not have been discovered had the telephone not been first invented. To these three marvellous instruments we have now to add a fourth, which in a still more striking manner is the offspring of the telephone. This is the photophone or "light sounder" of Professor Graham Bell and Mr. Summer Tainter.

In the speaking telephone, as is well known, the sound waves of the human voice are caused to strike upon a thin diaphragm and set it into sympathetic vibration. This vibration also acts upon an electric current, so as to vary the strength of it in a manner corresponding to the sound waves of the voice; and by leading this current along a telegraph wire and then by reversing the process so as to make it set a second diaphragm into audible vibration, we are able to transmit speech to a distant place by wire. There the electric current is simply the swift medium for conveying the sound from one place to the other, and it does so in virtue of the undulatory character impressed upon it. We might reasonably ask, then, if nothing else will do instead. A ray of light travels through the air with still greater velocity than an electric current along a wire. Are there no means whereby an undulating beam of light can carry sound? Professor Bell has shown us that there is, and taught the "golden silence" of the sunshine to laugh and sing and speak.

The suggestion of the Photophone occurred to Professor Bell in the winter of 1878 when he was lecturing at the Royal Institution. There is a substance named selenium, which is peculiarly sensitive to light, for when a ray of light falls on it an electric current will more easily flow through it than when it is kept wholly in the dark. If then, we make the current to flow at the same time through a telephone, the impact of the ray of light on the selenium will cause such an increase of the current as will be audible in the telephone. Again, the cutting off the light will so diminish the current as to sound the telephone, and thus, as Professor Bell remarked, it will be possible

> "To hear a shadow fall
> Athwart the stillness."

Moreover, the stronger is the ray of light the less is the resistance which it offers to the current; and hence it follows that an undulating beam of light will set up corresponding undulations in the current, and these in turn will generate vibrations in the telephone which may be heard aloud.

Obviously, therefore, if we could devise an apparatus by which the sound waves of the voice could undulate a beam of light in sympathy with themselves, and project this beam to a distant place where it could be received on a piece of selenium through which a current flowed on its way through a telephone, we should be able to reproduce the original voice in the receiving telephone. As early as the summer of 1878 this idea occurred to one "L. F. W.," for in a letter to "Nature" dated Kew, June 3, he describes an arrangement of this kind. Such hints, moreover, interesting in an historical sense, are, however, of very little account in science unless they are followed up by experiment and practically tested. "L. F. W." appears to have contented himself with throwing out the suggestion, and to Professor Bell belongs the honour of inventing the photophone by dint of patient labour.

At the very beginning of his attempt he encountered serious difficulties. The intractable nature of selenium baffled all his efforts. This ambiguous material, which, like phosphorus and sulphur, is neither metal nor non-metal, was accidentally discovered by Berzelius, the great Swedish chemist, when he was groping for something else—tellurium—and the foundling has proved to be the more important substance of the two, for owing to its singular property of electric sensibility to light it has been chosen from among its humbler brethren and lifted into honour. The property in question was accidentally discovered by Mr. May, an assistant of Mr. Willoughby Smith, the electrical engineer, who had set Mr. May to measure the resistance of a piece of crystalline selenium with a view to employing it in testing submarine cables. Much to his surprise Mr. May found the resistance of the selenium vary in a strange manner when the light fell on it, and fortunately Mr. Willoughby Smith took the matter up and verified the effect, and then published it to the scientific world.

The striking effect was eagerly investigated by a number of scientists, who all agreed in referring it to the action of light, and the yellowish-green rays of the spectrum were found by Professor W. Grylls Adams to be the most potent to produce it. Mr. Robert Sabine demonstrated that there was a real diminution of the internal resistance of the selenium under the influence of light; but Professor Adams also showed that the observed increase of a current flowing through the substance was not entirely due to its loss of resistance but to the actual generation of a current in the selenium. This fact is a very important one, and will, perhaps, find its use hereafter in the transmission of optical

images by electricity. For the purpose of the photophone, however, the diminution of internal resistance under light is the main consideration. Dr. Werner Siemens found the decrease to obey a definite law. It is proportional to the square root of the intensity of illumination, and upon this basis he constructed a "photometer," or measurer of light.

This interesting apparatus is known as the "Selenium Eye." It consists of a hollow ball of blackened wood, formed of two halves which can be opened or shut like the lids of the eye. A little within the ball is placed a glass lens to focus the light which enters by the parted lids upon a sensitive selenium cell no bigger than a wafer, fixed at the back of the ball. From this organ two fine platinum wires lead to a voltaic battery and a delicate galvanometer. The current from the battery flows through the selenium cell and the galvanometer at once, so that when a ray of light falls on the selenium and diminishes its resistance the current increases in strength and the needle of the galvanometer indicates the change upon a graduated scale. The deflection on the scale thus becomes a measure of the diminution of resistance, and hence of the intensity of the ray of light. There is a wonderful, nay fearful, likeness between this curious little instrument and the human eye. The movable eye-lids or shutters are present in both, as well as the crystalline lens, while the selenium cell with the conducting wires, voltaic battery, and galvanometer, are paralleled by the optic nerves and the brain. Moreover, there is another similarity which is fatal to the use of the "selenium eye" as an exact photometer. After exposure to the light repeatedly or for some length of time, the selenium cell loses its sensibility to light, and the galvanometer does not respond so strongly as before. The selenium, in fact, becomes fatigued, and like the living eye requires to rest ere it regains its former power. This tendency to physical fatigue was one great difficulty which Professor Bell had to contend with in adapting selenium to the photophone. Another drawback which he had to overcome was to the variable and uncertain nature of that body. Selenium occurs in two forms, the amorphous or vitreous, and the crystalline or metallic form. In the vitreous condition it is a non-conductor of electricity, in the crystalline state it is a conductor, but it has a fickle way of passing from the crystalline into the amorphous form, so that its resistance is apt to vary in an unexpected manner. Professor Bell found it best to crystallise it by annealing it in a crucible at a temperature of 210° centigrade for 24 hours, and then allowing

it to cool slowly for 60 hours. With conductive selenium thus prepared he constructed his photophonic cell for receiving the transmitted light.

Fig. 1 represents this device, which combines a low resistance of the selenium with a large receptive surface. It consists of a number of round disks or "washers" of brass, about 2 inches in diameter, arranged side by side on axles, T T, but separated from each other by disks of mica of slightly less diameter. These are clamped together in close

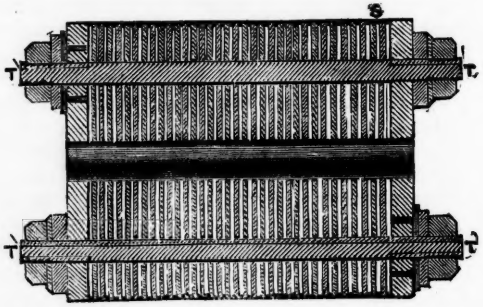

FIG. 1.—The Selenium Receiver.

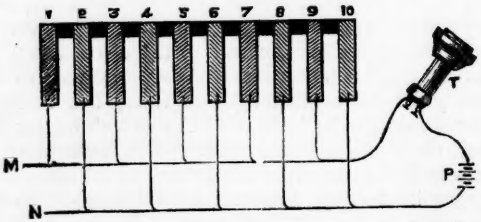

FIG. 2.—DIAGRAM SHOWING THE ACTION OF THE SELENIUM RECEIVER

file, and the grooves formed between the edges of the mica and brass are filled up with melted selenium, S, which is then annealed in the manner described, and the surface of the whole turned smooth in a lathe. The alternate brass disks are connected together, the first to the third and fifth, the second to the fourth and sixth, and so on, in the way shown in Fig. 2 at M and N, so as to give a circuit through the selenium surface, the battery, P, and a receiving telephone, T. A double cell of this construction is then placed

in the focus of a silvered reflector of parabolic contour, and the photophone receiver is complete.

Fig. 3 represents this reflector, c c, with the cell, s, in the focus, and the requisite attachments of battery and telephones. The transmitting apparatus consists of a mirror, M, reflecting a beam of sunlight through a lens, and (if

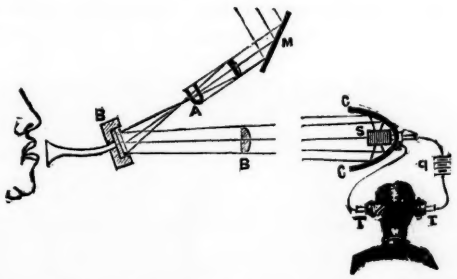

FIG. 3.—Theoretical Diagram of the Articulating Photophone.

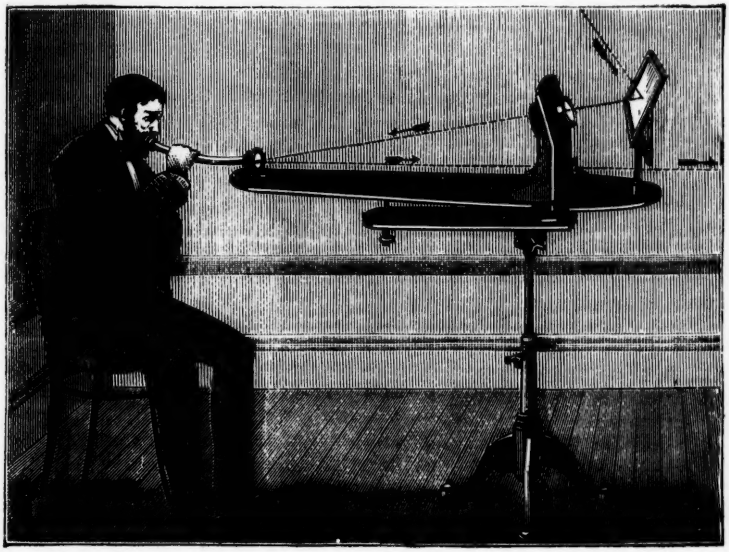

FIG. 4.--The Articulating Photophone. The Transmitter.

for the sake of experiment it is desired to cut off the heat-rays) likewise through a cell (A) of alum water upon the transmitter, B. This is simply a diaphragm of thin flexible glass, silvered on the outside to reflect the light, and fitted into a frame which carries an india-rubber tube and mouth-piece, permitting a person to speak against the back of the glass. A second lens, R, interposed in the path of the beam of light after it is reflected from the mirror, renders the rays parallel, and they travel in that condition until they are focused by the receiver, C C, upon the selenium cell, S.

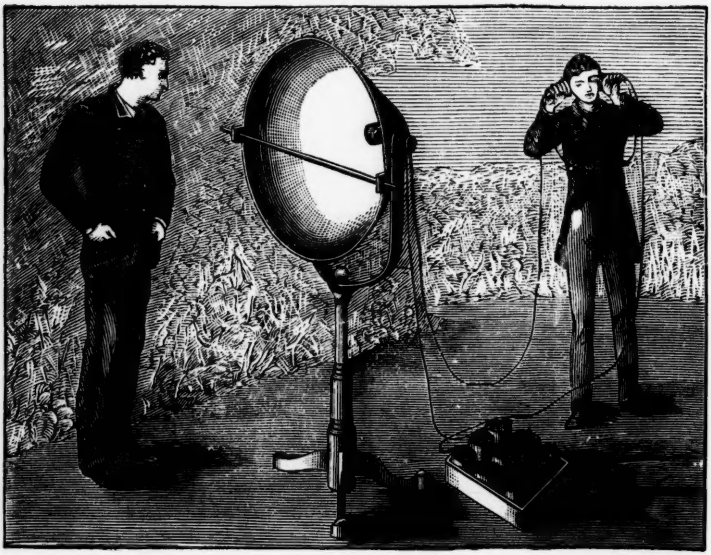

FIG. 5.—The Articulating Photophone. The Selenium Receiver.

In sending the photophonic message the sound-waves of the speaker's voice put the silvered diaphragm into vibration and undulate the beam of light, which on reaching the receiver varies the resistance of the selenium in a sympathetic mode, and reproduces the original voice in the telephones, T T, at the listeners' ears. Figs. 4 and 5 illustrate the operation of the photophone on a larger scale. When sunlight is not available the electric light may be employed, but it requires to be obtained from a very steady lamp, else the

flickering will be audible in the telephone as a crackling sound which tends to drown the voice.

It is obvious that the photophone is the perfection of the heliograph, just as the telephone may be regarded as the perfection of the telegraph. But in each case the crowning instrument has a shorter range than its cruder forerunner. The telephone is dumb on the long wires which readily convey the signals of a telegraphic message, and the photophone would fail to speak over the great distances which are intelligibly bridged by the flashes of the heliograph. Nevertheless it will be possible to photophone for a considerable distance, and even thus early Prof. Bell has succeeded in speaking along a beam of light 830 feet long. His account of the experiment is worth repeating. A transmitting apparatus, similar to that shown in Fig. 4, was placed on the top of the Franklin School-House, at Washington, and a selenium receiver, like that in Fig. 5, was stationed in the window of Prof. Bell's laboratory in L Street, in the same city, 830 feet away. "It was impossible," says the inventor, to converse by word of mouth across that distance; and while I was observing Mr. Tainter on the top of the schoolhouse, almost blinded by the light which was coming in at the window of my laboratory, and vainly trying to understand the gestures he was making to me at that great distance, the thought occurred to me to listen to the telephones connected with the selenium receiver. Mr. Tainter saw me disappear from the window, and at once spoke to the transmitter. I heard him distinctly say, 'Mr. Bell, if you hear what I say come to the window and wave your hat.' It is needless to say with what gusto I obeyed."

This feat proves that the photophone will yet be employed in military tactics, and probably also in correspondence between ships at sea, or perhaps between a shipwrecked vessel and the shore. Moreover, light will penetrate water, and we can even suppose a submarine photophonic talk. The method is of course in its infancy, and will doubtless be perfected in course of time. Already it has realised to some extent the far-reaching truth of the poet, that "light is the voice of the stars." For the changing brightness of the photosphere produced by solar hurricanes has revealed itself to Prof. Bell and M. Janssen in the photophone as feeble echoes, like the murmuring noise due to the flickering of the electric light.

It often happens that in pursuing one line of research a man of science is led into another; and Prof. Bell, in seeking to improve his photophone, arrived at what appears to be a

new discovery of moment. It has long been known that when a bar of iron is rapidly magnetised and demagnetised

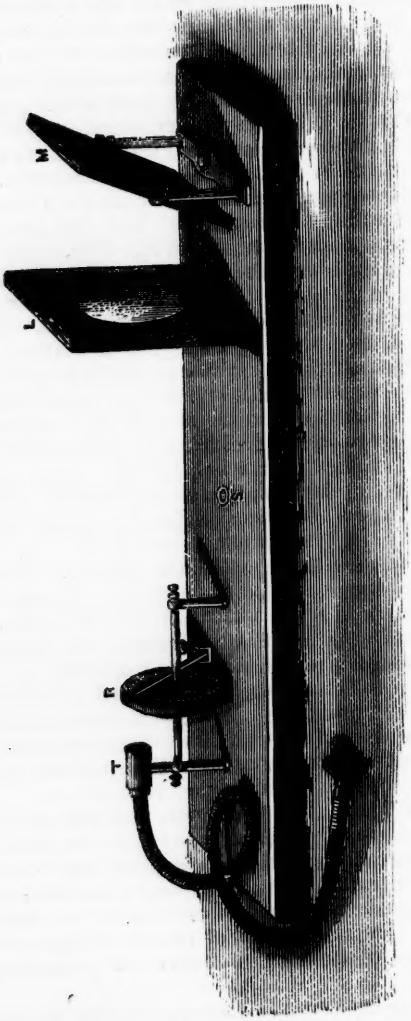

Fig. 6.—The Musical Photophone.

it gives out a musical note of a pitch corresponding to the number of magnetic impulses per minute; and Prof. Bell

found that all kinds of diverse bodies were rendered tuneful by the impact of an intermittent beam of light. Thin disks of wood, glass, metal, ivory, india-rubber, and so on, yielded a very distinct note. The apparatus he devised for these experiments is illustrated in Fig. 6, where M is a mirror reflecting a powerful beam of light from the sun or an electric lamp, through a lens, L, and in the path of the beam is mounted a rotating wheel, R, perforated round the rim with a circle of holes. This wheel acts as a screen to the light, except when one of the holes comes opposite the track of the beam. The latter then passes on to a pair of lenses, T, which direct the parallel beam toward the surface of a thin disk of the material under examination. When the wheel is rotated, the intermitted beam of light falling upon the disk behind causes it to ring with a musical tone whose pitch depends on the number of flashes per minute, and the ear-tube attached enables the listener to hear it without interference. This musical photophone is in reality a light syren, like the air syren of Cagniard de la Tour, in which the puffs of air escaping through the holes of a revolving disk emit a note. The disk form, though advantageous, is not essential to the effect. Crystals of sulphate of copper, chips of pine, even tobacco-smoke held in a glass test-tube before the beam, are found to yield a beautiful tone. Nor is it necessary that there should be light; for if the light-rays be cut off by a thin sheet of hard rubber or vulcanite, the invisible heat-rays which pass through the opaque screen are capable of producing the effect. Indeed it is still a moot point among investigators whether the effect may not be due entirely to the vibratory expansion and contraction of bulk due to the recurring blows of the heat-rays. So distinct is the effect that the naked ear held to the disk appreciates it, and even the outer ear itself acts as receiver, for when the intermittent beam is simply focussed in the aural cavity a faint musical note is heard.

Besides their practical promise, these interesting achievements of Prof. Bell have a poetic bearing. We are at once reminded of that mystical stone of Memnon which the sunshine made harmonious, and can imagine how the chequered sunshine of the trembling leaves is musical to finer ears than ours. In Dean Milman's "Martyr of Antioch" the god Phœbus-Apollo is invoked by the chorus of maidens as—

> "Lord of the speaking lyre
> That with a touch of fire
> Strik'st music which delays the charmed spheres."

And truly the deep connection between light and music is

curiously exemplified in the photophone. Prof. Bell, indeed, has played the part of a god, for has he not inspired a ray of light? Great as his invention is, however, it is probably but the stepping-stone to one still greater which is to come, namely, the transmission of light itself by means of electricity.

For the illustrations to the above article we are indebted to the courtesy of the publisher of the "Engineer."

IV. THE RADIOGRAPH AND ITS USES.

AN important step has just been taken in the difficult science of Meteorology. Before the final goal of prevision could even be conceived of as attainable, it was necessary that all those points which distinguish between season and season, and between climate and climate, should be regularly observed and put on record. In this direction wonderful advances have been made. We note the daily rainfall, the direction and the velocity or pressure of the wind, the degree of atmospheric moisture, and the maximum, minimum, and mean temperature. But as regards this last item, temperature, there was till very lately a great deficiency in our observations, all self-registering thermometers notwithstanding. Suppose that on the 13th of August last a certain temperature was observed. Was this degree of heat due to the action of clear sunshine, or to a current of warm air though the sky was overcast, or to a combination of the two agencies? It will easily be seen that this question is of moment, since the two kinds of heat differ in their action upon vegetable and animal life. Thus bright sunshine is necessary for developing the flavour of fruits and the aroma of flowers, and for ripening the grain, whilst warm air, unaccompanied by direct sunlight, is desired for the germination of seeds and the earlier growth of plants. Hence if our meteorology is to explain why certain crops succeed better in one summer than in another, and in France or America better than in England, it must be prepared to show which of these two sources of heat plays in such season or country the more prominent part.

It will be seen that, in registering the amount of direct solar action at any place, there are two variable quantities to be regarded whose product yields the total sought. There

is duration of action, *i.e.*, the number of hours during which the sun actually shines. This quantity is given by the length of the day *less* such time as it is obscured by cloud or fog.

The second quality is intensity. Everyone must have noticed that the efficacy of the sun's rays is very much greater in the middle of the day than in the early morning or late evening, and also greater when the sky is clear and the air transparent than when the one or the other is dimmed with haze or smoke.

Instruments are already in existence which register one of these factors without the other, and consequently give an imperfect answer to the question. Thus there is the so-called vacuum solar radiation thermometer which is in action in some meteorological observatories. It is a self-registering maximum thermometer with a blackened bulb, enclosed in an outer case of thin glass, exhausted as far as possible of atmospheric air. This instrument shows doubtless the greatest intensity of solar radiation reached, but it gives no sign whatever as to whether this maximum has prevailed for ten minutes or for five hours.

On the other hand, there is an instrument which has obtained a kind of official recognition which records duration without giving any accurate notion of intensity. It consists of a burning glass which concentrates the sun's rays upon a band of paper moved by clockwork at a regular rate. When the sun is shining the paper is burnt to charcoal in a continuous line. As soon as a cloud comes over the sun the action ceases. In consequence of the movement of the paper it is possible to observe during how many hours and minutes this carbonising action has been going on. Whether the sun has shone with just sufficient intensity to scorch the paper, or with twice that intensity, it cannot be made to appear.

As an improvement on this rude contrivance Mr. D. Winstanley, F.R.A.S., lately of Blackpool and of Paris, but now of Richmond, has devised the instrument of which we give a figure.

The instrument consists essentially of a firmly fixed and sensitive balance, carrying a mercurial thermometer, or rather thermoscope, fitted at each end with a glass bulb (T T') containing air. The former of these bulbs alone is exposed to the sun : A B are balls for adjusting the equilibrium of the balance, and C D are stops which prevent it from tilting too far. When the sun shines on T the air within expands, and drives the mercury to the right along the horizontal

tube, and thus displaces the centre of gravity. In consequence, the right arm descends till the pencil F touches an hour-dial placed below it, and made to revolve by clockwork. So long as the sun shines the pencil remains in contact with

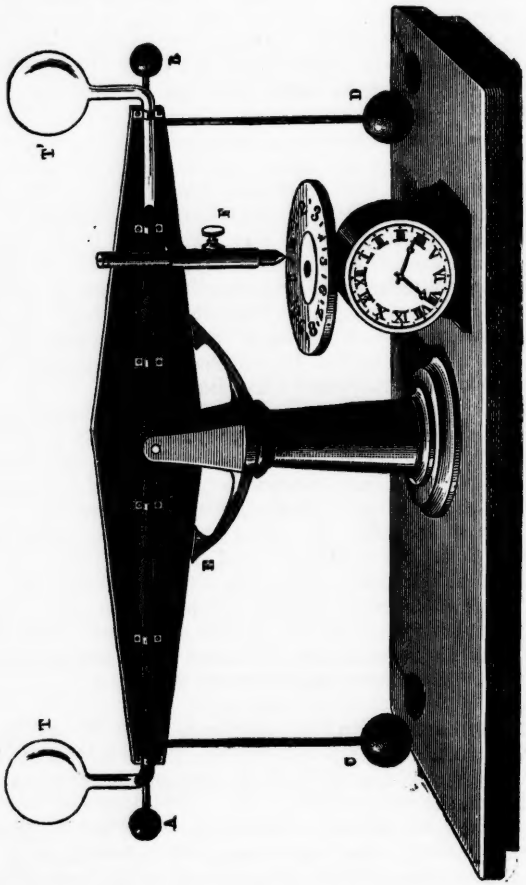

FIG. 1.—Winstanley's Apparatus for recording the Duration of the Sunshine.

the paper on the dial, and leaves a mark as the latter revolves, as shown in the outer line A A A, Fig. 2.

As soon as the sun is overcast the air in T′, acting like a spring, drives the mercury back to the left; the balance

tilts, lifting the pencil up from the paper on the dial, which then continues to revolve without receiving a mark. In the example shown in our figure the sun began to shine a little after 6 a.m., and continued with short intervals till 4.15 p.m. An occultation, even of the length of a minute, was distinctly recorded.

The inventor of this most ingenious contrivance perceived, however, at once, that it was open to the same objection which we have already pointed out, giving duration of solar action, but not of intensity. He therefore went to

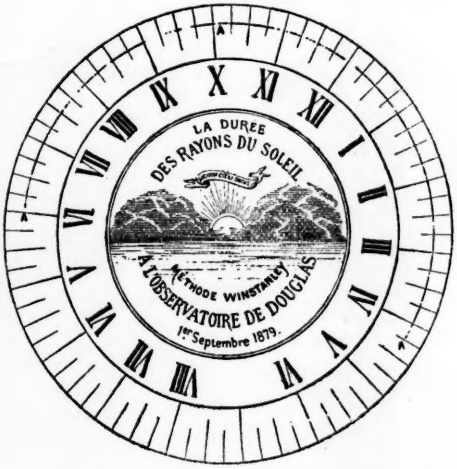

FIG. 2.—Facsimile of a Record of the Duration of the Sunshine made by the Apparatus Winstanley.

work again, and devised an apparatus to record both the quantities in a manner which leaves nothing to be wished for.

This instrument, which Mr. Winstanley names the "Radiograph," is shown in the subjoined figure. It consists of a curved tube fixed along the greater part of the circumference of a brass wheel, and carrying at its ends the balls B and A, the former of which is blackened. The wheel turns at its centre on knife-edges of hardened steel resting on agate planes. The lower half of the tube is filled with mercury, and the bulbs are sealed so that the inclosed air cannot escape. The wheel carries a fine steel needle which

plays against a metal drum, made to revolve at regular speed by clockwork, and tightly covered with a piece of glazed paper which has been evenly smoked over at the flame of a tallow candle. As the rays of the sun fall upon B the air enclosed is expanded, and the mercury is driven towards A. In consequence the equilibrium of the wheel is disturbed, and the point of the needle makes a scratch on the fine coating of lamp-black.

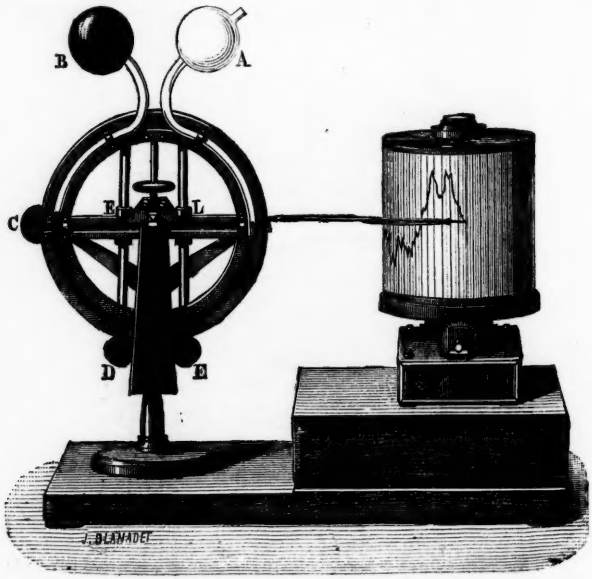

FIG. 3.—Winstanley's Radiograph; an Instrument which records continuously both the Duration and the Intensity of the Sunshine.

The slightest cloud passing over the sun acts upon the needle, leaving a distinct tracing upon the cylinder, which, in consequence of its rotation, is referred to the exact time at which it took place. Unlike the former instrument, the radiograph leaves an impression during the whole of the day. The feebler the light of the sun the lower is the line, as shown in the accompanying diagram. Here it appears that in the experiment thus recorded the radiation was greatest at noon, and declined then very rapidly for nearly an hour, rising afterwards almost to its former point. The

sudden alternations of sunshine and cloud, many of them of very brief duration, are shown admirably. The tracings

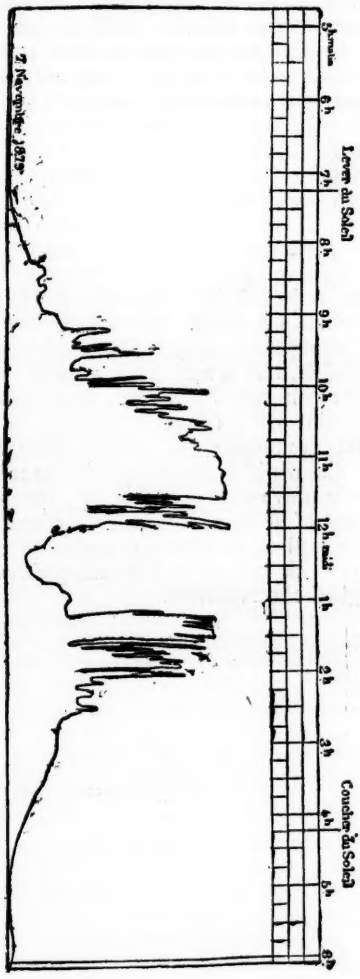

FIG. 4.—Facsimile of a trace made at Douglas, in the Isle of Man, by the Radiograph of Winstanley.

at the end of the day are fixed by means of weak lac varnish, and may then be preserved uninjured.

It must further be observed that the general temperature of the air and the barometric pressure do not affect the instrument, which works solely by the difference of pressure in B and A—a difference due to solar radiation alone. It is scarcely necessary to add the caution that the instrument must not be placed where radiant heat from walls, rocks, &c., which have been heated by the sun, may fall upon B. The radiograph is enclosed in a copper case, out of the top of which the bulbs project, and are protected against rain, &c., by a bell of thin glass.

It is remarked that the instrument gives slight signs of activity even before sunrise, and that the needle rises above what may be called the zero-line at midnight. This takes place with such regularity that it cannot be ascribed to accident.

It may be objected that the radiograph apparently indicates perpetual sunshine. We must, however, remember that even during the passage of the darkest clouds, the sun, though invisible, has a somewhat greater action than when he is below the horizon. We can often feel his rays when we cannot point out his exact position in the sky.

We must pronounce the radiograph a most important addition to the working resources of the meteorologist. It will certainly prove of great value in a comparative study of the intensity of solar radiation at different latitudes and altitudes, as well as in different states of the atmosphere. We trust the invention will be adopted without delay in meteorological observatories.

ANALYSES OF BOOKS.

Lorenz Oken ; a Biographical Sketch. Being a Memorial Discourse on the Centenary of his Birthday, delivered at the Second General Session of the Fifty-second Congress of "German Naturalists and Physicians" at Baden-Baden, September 20, 1879.* By ALEXANDER ECKER. Stuttgart: E. Schweitzerbart.

So rapid has been the advance of biological science in the latter half of the nineteenth century that, as the author truly remarks, "if we read Oken's 'Philosophy of Nature,' we seem to listen to the language of the remote past as if proceeding from the mouth of some Egyptian priest." Still, though the stream of time has swept over the discoveries and controversies of eighty years ago, —though all, and more than all, that Oken ventured to predict has been fulfilled,—we may be permitted to offer our humble tribute of gratitude to the memory of the man whose writings were to us once what a solitary branch of mulberry might be to a silkworm pining amidst a wilderness of thistles.

The author of the work before us disclaims the intention of furnishing—what we should gladly have seen—a thorough critical examination of Oken's scientific achievements. Still he places before us a faithful summary of the chief points upon which the fame of the great German naturalist must rest. To these subjects we must beg to draw the attention of our readers, referring to the outward features of Oken's life only in as far as may be needful for an understanding of his position.

Lorenz Oken was born, as the son of a poor peasant, in what may almost be called the pre-scientific time of 1779. Thanks to his inflexible will, to his integrity of character, his shining abilities, and the aid of friends who were attracted and secured by the latter attributes, he contrived, amidst many privations, to obtain a learned education, and in 1804 he graduated at the University of Freiburg as Doctor of Medicine. Even before this time he had come forward as an original investigator in biology. In his work on "Generation" (1805) he explains putrefaction as a catagenesis,—a resolution of the organic body into its primitive cells or protozoa, which he curiously enough terms "Infusoria." It may be fairly admitted that in this treatise he anticipated the modern doctrine of the cell, and its part in animal

* Lorenz Oken; eine biographische Skizze, Gedächtnissrede zu dessen hundertjähriger Geburt stags feier gesprochen in der zweiten œffentlichen Sitzung der 52 Versammlung deutschen Naturforscher und Aerzte.

and vegetable life. Whilst lecturing at the University of Gœttingen, where he acted as "Docent" (1805-6), he was engaged with the study of animal development, especially of the formation of the intestinal canal in the embryo of the Mammalia. His results were published in 1806, whilst Wolff's researches were only made known in Germany by Meckel's translation in 1812, and Pander's work did not appear until 1816-17.

Concerning Oken's treatise the late E. E. Von Baer remarked —"Highly as I value Dutrochet's and Cuvier's lessons on the development of the mammals, it appears to me undeniable that Oken's researches have been the turning-point for a more correct understanding of the mammalian egg." Still it must be confessed that he does not take a prominent rank among the observers of novel facts. We do not find him, like Cuvier and Hunter, dissecting every insect, mollusc, or reptile that came into his hands. Nor is he recorded as having, like White, concerned himself with the habits, the migrations, or the local occurrence of species. His strength lay in the detection of parallelisms and analogies; in generalisations and predictions, bold, sometimes successful, but too often rash. For it must be confessed he did not possess the grace of suspending judgment, but rushed to conclusions where it would have been more discreet to await further evidence. Among his forecasts we may cite the following:—"The fundamental material of the organic world is carbon; the carbonaceous mass must be at once solid and liquid, even slimy; everything organic proceeds from slime. The primitive slime from which all things proceed is the sea-slime." Here we have the theory of the Protoplasm and the Bathybius! Our modern authorities, too, speak of organic chemistry as the chemistry of carbon and its compounds. "The first step," says Oken, "from the inorganic to the organic is the conversion into a cellule." "The task of the philosophy of Nature is," he declares," to show how the elements and the heavenly bodies have arisen; how they (the former) have been developed into higher and more manifold types, and have appeared as minerals; becoming finally organic, and ariving at self-consciousness in man." Here, therefore, we have an explicit avowal of Evolutionism, rare in the earlier part of the century. In consequence he was occasionally, in England at least, denounced by the dominant Cuvierian school as a setter-forth of dangerous doctrines. We remember well feeling compelled to address a private letter of remonstrance to the editor of the "Zoologist" on occasion of a review of Oken's "Philosophy of Nature" (the Ray Society's translation) which appeared in that valuable journal.

Among Oken's other merits must be mentioned his earnest endeavours for the introduction of the natural sciences into the ordinary educational curriculum in Bavaria, and his controversy with Thiersh, the advocate of the word-mongers. Closely herewith connected was his laudable endeavour to minimise the pro-

portion of Greek and Latin words in scientific terminology. We can fancy the expression of his face if he had ever encountered such terms as "arctiodactyls" and "perissodactyls."

He also deserves, and is beginning to receive, due honour as the founder of the "Congress of German Naturalists and Physicians,' of which the British Association is a copy.

We cannot conclude this brief notice of Herr Ecker's interesting work without reference to one of Oken's greatest discoveries, which involved him in a dispute as to priority with the poet Goethe, and undoubtedly exercised a great and outwardly unfavourable influence upon his career. On entering upon his professorship at Jena (July 30, 1807) he published a small work which bears the title "The Signification of the Skull-Bones," and which gave a new direction to the doctrine of the morphology of the skeleton, by pointing out the homology between the skull and the vertebral column. It is evident that he had long entertained this idea, since as early as 1802 he had pronounced the organs of sensation to be merely a repetition of lower organs. In August, 1806, when taking a tour in the Harz in company with two students, he found by the Ilsenstein the bleached skull of a deer, and was at once struck with the analogy in question. He sent his work to Goethe, the "curator" of the University of Jena, and he writes—"This discovery pleased Goethe so that he invited me, in the Easter recess, 1808, to pay him a week's visit in Weimar, which I did." Nothing is known as to what passed at this interview, and it is remarkable, as Herr Ecker points out, that "Goethe, to my knowledge at least, never mentions Oken, though he otherwise followed with great interest much less important researches which bordered upon his own studies." Sixteen years after this interview, in 1824, Goethe laid claim to the priority of the discovery in his "Contributions to Morphology." He asserts that in 1791 he found the skull of a sheep on the Lido, at Venice, and was struck with the analogy. He adds, still without any mention of Oken, that "in 1807 this theory had been given to the public tumultuously and incompletely." The flatterers of the great poet have actually gone so far as to accuse Oken of having stolen the idea from Goethe—a charge for which there is not the slightest foundation. The two men never met until after the publication of Oken's work. No correspondence had passed between them, and Goethe had certainly not made his discovery public. The priority of publication and demonstration undoubtedly belongs to Oken, and we fear that Goethe, though he made no explicit charges against his co-discoverer, cannot be acquitted of having tacitly sanctioned their propagation by others. Hegel in particular had the indiscretion to say, without the shadow of proof, that Goethe had communicated his ideas to Oken (Hegel's "Werke," vol. vii., sect 1, p. 567; Berlin, 1842).

There was indeed, after the visit in 1808, a coolness between

Goethe and Oken, which the former evinced in a very unworthy manner. Making use of his position in the Weimar Government, he prevented Oken from delivering a course on botany in the Lecture-Hall of the Botanical Gardens at Jena. Worse than this, he took part—as a document quoted by Herr Ecker but too plainly shows—in the intrigues which led to the removal of Oken from his professorship and the suspension of his journal, the well-known "Isis."

We can add no more save an aspiration of "peace to his ashes and glory to his memory," and an expression of thankfulness to Herr Ecker for his able and faithful survey of the life and the struggles of the illustrious biologist.

Is Darwin right? or, the Origin of Man. By WILLIAM DENTON. Wellesley, Mass.: Denton Publishing Co.

THE work before us is one which may fairly claim our attention. The author is most decidedly an evolutionist. He argues ably against the advocates of mechanical creation, and in support of the "natural origin of man" he appeals to the metamorphosis of animals, to anatomical similarity, to linking forms, rudimentary organs, palæontological resemblance, geological succession, insular organic resemblance, the antiquity of our species, and to brutal characteristics. In all these respects, if no absolutely new facts are brought forward, the evidence is summarised with great clearness, and the objections to the theory of development are met in a masterly manner.

Mr. Denton belongs, however, to that—dare we say "increasing"?—party who, whilst fully accepting Evolution, and even recognising "Natural Selection" as a *vera causa*, consider it as insufficient to account for the existence of all organic forms, and especially of man. He has been led by his "investigations in mesmerism, spiritualism, and psychometry" to consider the theories of Darwin and Huxley deficient as ignoring "the spiritual side of the universe, infinitely its most important side." "Natural Selection" he regards as "the gardener that trims the tree of life, lops off the imperfect branches, and destroys the sprouts that might divert its energies, but not the Creator that gave life and form to the tree." Here, though on very different grounds, he will find thoughtful naturalists not a few who will agree with him, and who think the struggle for existence more likely to reduce than to increase the number of organic forms. Mr. Denton differs from the Darwinian school in rejecting haphazard variation as the grand agent in the production of species. He considers that Evolution has followed a plan in which purpose and wisdom are conspicuous. He enumerates certain

"pointers" which indicate that man's origin has been not merely human and brutal, but at the same time spiritual and divine. As such he enumerates the man-ward progress of our planet, the race-development of animals, the phenomena of organic distribution, the persistency of type, the multiplicity of human origin, language, the tendency to beauty, the human faculties, and the spiritual faculties.

Now we are by no means so much in love with "Natural Selection" as to suppose it capable of accounting for all the facts of organic existence, and we are far, very far, from wishing to ignore the considerations which Mr. Denton has brought forward. It may be mental feebleness on our part, but we do not see our way to a purely monistic interpretation of Nature, and we fancy that for those who do, or think they do, the future may have in store a startling revelation.

But we find in the author's arguments much to which we must demur. Thus we find him arguing in favour of spontaneous generation, or *abiogenesis*, as it is now officially called. After giving an account of the experiments of Tyndall, he proceeds:—"The experiments of Wyman, Mantagazzi, Bastian, and a host of others who have found living beings in sealed glass vessels after they had been exposed to a heat much more than sufficient to kill germs if they had existed, can never be negatived by such experiments as Tyndall's, were they multiplied a thousand-fold." Now we should regard it as a most splendid triumph if life could be produced from inorganic matter under circumstances where the intervention of antecedent life was demonstrably impossible. But this is precisely what has not been done. Germs are found capable of bearing temperatures much higher than had been formerly supposed. But if the exposure of heat is sufficiently high, sufficiently prolonged, or often repeated, then no life appears. No experimentalist in this direction has had so much practice as M. Pasteur, and where the precautions which he indicates have been rigorously followed we do not hear of any affirmative result.

Elsewhere we find the existence of "essentially human faculties" adduced in proof of the spiritual origin of man, of his being an approximation to a type of perfection. Says the author:—"Phrenology as taught by Dr. J. R. Buchanan is as much a true science as geology taught by Sir C. Lyell, and can be much more readily demonstrated. This science reveals in man the existence of reverence, modesty, benevolence, chastity, integrity or conscientiousness, &c." Now without pointing to the discrepancy of the results obained by modern cerebral physiologists, *e.g.*, Hitzig and Ferrier, from the doctrines of the phrenologists,—without asking why mental faculties should be located merely in those portions of the grey matter which underlie some portion of the skull accessible and measurable during life,—we may point out that to distinguish, by any clearly-marked

characters, the brain of the mias from that of man is confessedly "the anatomist's difficulty." But if every faculty is located in an especial portion of the brain, and if certain faculties present in man are wanting in the ape, then it follows that certain regions of the brain must be wanting in the latter, and the anatomist could not fail to be struck with the difference. Further, benevolence and even conscientiousness are clearly to be traced in the actions of the higher brutes. Hence we may legitimately look with an eye of suspicion upon an alleged science which takes such grounds.

The spiritual faculties in man—*i.e., clairvoyance*—are next adduced as a gift which cannot be accounted for by the action of Natural Selection. We do not, be it known, presume to refer these phenomena to "DOMINANT IDEAS," but surely they are still too much matter of dispute to be brought forward on such an occasion.

Of much more value are the considerations urged under the head "Persistency of Type." If organic forms are the results of casual variation, weeded out by natural selection, the question may surely be asked why they are confined within so limited a range? It has often been pointed out as unexplained that no vertebrate animal has more than two pairs of limbs. But the author here hazards some remarks which we can scarcely call judicious. He asks, "Among reptiles, why not the first indications, at least of a transformation of the fore feet to wings and the appearance of feathers?" Need we remind him of the pterodactyle and the archæopteryx, both of which he figures in this very work? Again it is said—"Why not some indications of hands to take the place of the hoofed feet of horses and cattle?" Because in that group development has been moving in the very opposite direction, as he himself shows in figures taken from Marsh. "A pair of eyes at the back of the head and a pair of arms to correspond" would involve fundamental alterations in the entire skeleton. Where would the shoulder-blades and the muscles for the extra pair of arms be fixed? Should such ever appear they would scarcely begin with "buds behind the shoulders of some babies." "A telescopic eye" would in most spheres of life be useless, or rather harmful to its possessor.

The remarks on language we cannot accept, and we regret to find him using the worn-out phrase "dumb animals." Brutes have developed languages, and we have no right to term them dumb because such languages are to us unintelligible.

An important idea, which the author presents more than once under varied forms, is this:—"The tree never advances beyond its fruit, and I believe the tree of life fruited when man appeared." If Mr. Denton is herein correct the task of Evolution is ended, and we need not wonder if no new forms can be detected in the act of making their appearance.

We differ from the author on many points, and on others we are doubtful, but whilst the theory of the origin of species is still so far from completion we would listen to every candid contribution that is offered.

United States Commission on Fish and Fisheries. Part VI. Report of the Commissioners for 1878. Washington: Government Printing-Office.

This important and bulky return comprises an inquiry into the decrease of food-fishes, returns on the propagation of such fishes in the waters of the United States, and, in addition, several useful appendices. In noticing this work there is one preliminary reflection which we are unable to suppress: what an immense supply of food—capable, moreover, of great extension—we must be content to abandon if the Vegetarian party should succeed in enforcing their views!

The author of this Report, Spencer F. Baird, justly remarks that "wherever the white man plants his foot, and the so-called civilisation of a country is begun, the inhabitants of the air, the earth, and the water begin to disappear," and he adds that "the cause of this rapid deterioration is not to be found in a reasonable destruction for purposes of food, of material for clothing, or other needs. It is only as the result of wanton destruction for purposes of sport, or for the acquisition of some limited portion only of the animal, that a notable reduction is produced, and the ultimate tendency to extinction is initiated." In confirmation of these views we find statistics proving the fearful decrease of food-fishes in the rivers and the shore-waters of the Eastern States within the last half-century. It will be well for mankind if they can be brought to see how suicidal has been their conduct. Better still if future generations cease to look upon the taking of animal life as an amusement. The difficulties to be encountered in making the ocean supply a fair quota of food for the increasing population of the dry land are very serious. There is wanton or ignorant destruction to be checked; there is the scientific propagation of fish to be elaborated and extended; and there are, in England at least, monopolist middle-men to be hunted down, who have proved deadly enemies alike to the producer and the consumer.

In all these directions there is still much to be done and much to be learnt. The natural-history of many food-fishes is still so imperfectly known that it is by no means certain what times and modes of capture interfere least with the multiplication of these creatures.

As regards pisciculture our knowledge is decidedly in advance

of our practice. We give an instance :—The raising of carp has long been found in North Germany a fairly profitable business. Farms in watery situations are very frequently fitted up with a series of properly arranged ponds for the young fry, for the larger carp, and a wintering-pond. The former are shallow, but for the latter a depth of 8 to 12 feet is required. It is found that in many seasons more money can thus be realised from an acre of fish-pond than from an acre of arable land or pasture; and it is somewhat strange that our farmers, in their very natural anxiety for profitable means for utilising the soil, have done so little in this direction.

The culture of carp is described very thoroughly in this report. In Upper and Nether Lusatia the production of carp amounts to from 8000 to 10,000 cwts. A single German breeder of gold-fish raises annually 300,000. He employs fifteen labourers, a night-watchman, and a book-keeper, besides the men employed at his sale-rooms in Berlin. All these persons earn a good livelihood, and the profits are considerable.

Passing from these practical facts, it must be noted that the present report contains very valuable contributions to the natural history of the herring, the cod, and certain of the Salmonidæ, especially the Californian salmon.

The liberality of the American Government in supplying not merely valuable information on pisciculture, but in forwarding large supplies of the ova of esteemed food-fishes to New Zealand, Tasmania, &c., deserves the warmest acknowledgment.

A Polar Reconnaissance. Being the Voyage of the *Isbjœrn* to Novaya Zemlya, in 1879. By Albert H. Markham, F.R.G.S. (Captain Royal Navy). London : C. Kegan Paul and Co.

Captain Markham is evidently an enthusiast in the cause of Arctic exploration. The voyage here narrated may be looked upon as a feeler serving to ascertain the most hopeful track for a future Polar Expedition. The author, from his own experience, endorses the view of Sherard Osborne, that, in order to penetrate into the still unknown north, it is necessary to find a coast-line trending northwards with a western aspect. As such he selects the west coast of Franz Josef Land, stretching to the north from 80° lat. He considers it essential, however, that the Expedition should be prepared to spend a winter in the ice, and to send out extensive sledge parties.

The first part of this work contains an account of earlier voyages to the north-east—English, Dutch, Russian, Norwegian, Austrian, and Swedish. The author regrets the comparatively

unimportant part which England has latterly taken in the task of geographical discovery. That such is the case is true. Even within the boundaries of the British Empire, and in regions immediately contiguous, there is very much still unknown, and we, with our unequalled facilities and with the most urgent motives for exertion, are not doing what might fairly be expected. Still we can scarcely sympathise with Capt. Markham's especial predilection for the Polar regions. It seems to us that, for instance, a thorough exploration of New Guinea would be more valuable to Science than the most minute survey of the unknown regions around both poles! The geology of these latter lands is generally masked under snow and ice, and their biological features are very scanty.

The cruise of the *Isbjœrn* was primarily of a sporting character, Sir H. Gore Booth, who invited the author to accompany him, being intent on walrus-shooting on the coasts of Novaya Zemlya. Leaving England by the mail-steamer *Tasso*, for Trondjem, they embarked in the Norwegian mail-boat *Lofoten*, which plies between the latter town and Tromsö. Here difficulty arose on account of a dog belonging to Sir H. G. Booth, and which, according to the Norwegian protectionist system, was contraband. Though its owner had no intention of landing it on Norwegian soil at all, it could not be taken on board the *Lofoten*, but had to be left at Trondjem until certain formalities had been completed, and was then taken northwards in another steamer, secured by a chain to a bolt in the deck, and with the official seal of the Customs on its collar. We have heard of a yet stranger case:—An Anglo-Norwegian firm, who carry on the manufacture of fish-manure in the Loffoden Islands, sent over a cargo of potatoes for the use of their workmen there. It was found, however, that the roots could not be landed even on payment of duty. The ship's crew had to eat the potatoes on board, and an official came every day to see and to certify that the parings were duly destroyed by fire!

In Novaya Zemlya the travellers found during the brief summer a somewhat luxuriant vegetation, including a beautiful purple saxifrage, a bright yellow poppy, and the forget-me-not. The birds of this hyperborean region are, of course, chiefly sea-fowl. The author states that a couple of glaucous gulls endeavoured to warn a seal which Sir H. G. Booth was quietly approaching with murderous intent, and as it took no heed of their screams they at last alighted on the ice, walked up to the seal, and pecked him, when he at once dived down into the water. Foggy weather, the explorers found, accompanied high winds, whether from the south-west or north-east, and bright clear weather almost invariably ensued in a dead calm. The reindeer in Novaya Zemlya, which are by no means scarce, seem to subsist during the winter on the fat they accumulate during the summer. The common account of their sweeping away the snow in order to

browse upon the plants hidden beneath is questioned by Captain Markham, as the snow is several feet deep, and as all vegetation withers at the end of summer. At the head of Schubert Bay the author captured a few butterflies. The author saw none of these insects on any day save August 4th, and he thinks that their life in the mature condition must be probably less than a week.

Commodore Jansen, of the Dutch navy, suggests the establishment of meteorological stations along the coasts of Lapland and Siberia. Observations taken there would, the author thinks, aid much in deciding when a favourable season for Polar expeditions might be anticipated.

A number of Appendices on the scientific results of the voyage are subjoined. Sir J. D. Hooker reports on the plants; Captain Feildon on the birds, of which twenty-six species were captured and three others identified; E. J. Miers gives an account of the Crustacea; E. A. Smith describes the Mollusca; F. J. Bell, the Echinodermata; H. B. Brady, the Rhizopoda; Mr. Etheridge, the geological collections; R. McLachlan, the insects; and Dr. Günther, the fishes.

The results of the voyage may be pronounced decidedly valuable, especially if we consider its very limited scale and brief duration. The book, in addition to its scientific interest, contains much which cannot fail to gratify the lovers of adventure.

Education. An International Magazine. Bi-monthly. Devoted to Science, Art, Philosophy, Literature, and Education. T. W. Bicknell, Conductor. Vol. I., No. 1. Boston: New England Publishing Company. London: Trübner and Co.

We have here the first number of a new journal, thoughtful, ably conducted, and if breathing a spirit somewhat strange to us not on that account the less interesting. We find, indeed, here and there utterances which somewhat surprise us. Thus we read—"The State has always a means of limiting, if necessary, the number of those who seek a high education, and casting aside those who have not the capacity or the endurance; they may increase the standard of examination for admission and graduation so as to secure that only the highest scholars pass." Unfortunately examination is no test of the originating power, and those "cast aside" may easily happen to be the very best men—the inventors and discoverers.

Another writer quotes a saying of a professor of the John Hopkins University, "that the English people are divided into

two classes, examiners and examined,"—quotes it, too, not in ridicule or in pity for a nation which is thus following the example of China, and deliberately rendering itself incapable of original thought!

An editorial article, on the "Mundella Education Bill," speaks of the "quiet and unobtrusive manner of its introduction into the new educational structure of England's coming greatness." Whilst appreciating the kindly feeling here brought to light, we fear "England's coming greatness" is an exceedingly questionable matter. Perhaps, in consideration of what we once were, the leading powers of the future will permit us to go on passing examinations, making speeches, laying wagers, and founding sects and philanthropic movements.

Elsewhere the editor speaks of "interpreting the whole universe by the nobler key of Plato, Aristotle, and Hegel, rather than by the dog-headed and monkey-tailed ciphers of Darwin and Haeckel!" Such remarks carry with them their own criticism.

Practical Botany for Elementary Students. Introductory to the Systematic Study of Flowering Plants. By D. HOUSTON. (Stewart's Educational Series.) London: W. Stewart and Co. Edinburgh: J. Menzies and Co.

THE work before us is of a practical character. The student is told how and what to observe; the instruments needful are described in the introduction, and the plants selected for examination are well known and easily procured types of the fifteen natural orders included in the "Syllabus of the First Stage of Elementary Botany issued by the Science and Art Department." The author believes that no better selection of natural orders, as an introduction to the study of classification, could possibly be made. As one of his order-types the author takes the common buttercup; he directs the examination of its roots, root-stock, aërial stem, leaves, inflorescence, flower, and fruit. Of these parts the flower and fruit are most closely scrutinised, using the lens, and making certain sections. Notes are to be taken and sketches drawn. From the particulars observed the pupil learns why the buttercup is referred to the class Dicotyledons, the division Polypetalæ, the subdivision Thalamifloræ, and the natural order Ranunculaceæ. A list is then given of other well-known plants belonging to the same order, and reference is then made to its general properties and uses, and to its geological and geographical distribution.

It is very evident that the student who has carefully worked

through the fifteen representative plants here described will possess an amount of knowledge such as he could never acquire from books alone, or from the mere cursory and superficial examination of specimens. It is therefore at once a duty and a pleasure to recommend this little volume.

Dimensions of the Fixed Stars. With especial reference to Binaries and Variables of the Algol Type. By EDWARD C. PICKERING. Cambridge (U.S.): J. Wilson and Son.

THE author proposes to give a full trial to the method taken in the case of satellites and small planets,—in other words, to deduce their dimensions from the amount and character of their light. As a result of this method, he gives for the two components of *α Centauri* the respective magnitudes of 1·82 and 0·46 times that of the sun.

As regards variable stars of the Algol type, where a maximum and minimum of brightness succeed each other periodically, the author discusses several theories, and favours the supposition that the variation in light is due to the interposition of a non-luminous satellite.

This memoir is reprinted from the "Proceedings of the American Academy of Arts and Sciences," vol. xvi.

The Journal of the Royal Historical and Archæological Association of Ireland. Vol. V. Fourth Series. No. 41.

THIS number contains an account of a megalithic structure at Mongnacool Lower, County Wicklow, locally known as the Fairy House. No traces of urns have been found, nor is there any appearance as if the ground had been disturbed by treasure-seekers. There is also a notice of a flint knife and an ornamented bronze celt found in the County Tyrone, a region where the manufacture of such implements appears to have been extensively carried on. About five years ago a large collection of bronze arms and tools, all damaged, was found hidden beneath a huge block of stone in Bo Island, in Lower Loch Erne.

Journal and Proceedings of the Royal Society of New South Wales. 1879. Vol. XIII. Sydney: Thomas Richards. London: Trübner and Co.

We cannot express ourselves as well satisfied with the work done by the Society during the year 1879. The Biological Section has given no sign of life; the Geological and Palæontological Section has been merged in that for Chemistry and Mineralogy; and the amalgamated body has held only four meetings, at which nothing of importance took place.

Among the proceedings of the Microscopical Section we note an interesting paper on some recent objectives manufactured by Carl Zeiss, of Zena, communicated by G. D. Hirst; and notes on Tolle's duplex front 1-10th immersion objective, in comparison with Zeiss's oil immersion 1-8th (No. 18) by both oblique and central light, by H. Sharp. The writer considers that the Tolles lens, compared with Powell and Lealand's new formula 1-8th, has greater working distance, is more achromatic, gives superior definition, and in flatness of field is not inferior. "With water-immersion, either by oblique or central light, in resolving power, clearness and brilliancy of definition, and extraordinary penetration, this 1-10th Tolles is unequalled by any water-immersion objective I have yet seen." By oblique light it is somewhat inferior to the Zeiss, but with direct light the latter is quite eclipsed by the Tolles.

Mr. T. E. Hewett describes an improved dissecting microscope, the power being Sir J. Herschel's plano-convex doublet, which has seldom, if ever, been applied to microscopes.

The Royal Society of New South Wales has, curiously enough, a Section for Literature and the Fine Arts, the doings of which fill up no inconsiderable portion of the volume.

The Vice-President, Prof. Smith, C.M.G., in his Anniversary Address, referred to the loss which the Society had sustained by the death of the zealous geologist, Rev. W. B. Carke, the true discoverer of gold in Australia.

Records of the Geological Survey of India. Vol. XIII., Part 4, 1880.

In this issue Mr. W. Theobald describes the Pleistocene deposits of the Northern Punjab, and considers that they afford evidence of an extreme climate, and probably of glaciation, during a portion of that epoch.

Mr. C. A. Hacket gives an account of the useful minerals of the Arvali region. The copper mines of the district appear to

be exhausted; but blue vitriol, alum, and copperas are obtained from the weathered shales and other refuse of the mines. All these products contain traces of nickel and cobalt.

Dr. Feistmantel shows that the unconformity existing in Africa, India, and Victoria, between the Ekka beds, the Talchir beds, and the Bacchus marsh-beds and their underlying rocks, is in New South Wales filled in between the Hawkesbury rocks and the Devonian beds of the series of the Australian coal-beds.

Mr. W. Center and Mr. H. B. Medlicott deal with the important question of the "Reh" or alkaline soils of Upper India, and the saline efflorescence so fatal to agriculture.

Report of the Entomologist of the United States Department of Agriculture for the Year 1879. By J. HENRY COMSTOCK. Washington: Government Printing-Office.

THIS treatise contains an account of a serious catalogue of vermin, all of which claim for their share no small part of the fruits of human industry. Cotton, grain, clover, the orange tree, the vine, the sugar-cane, the potato, the cabbage—all have their special enemies. Fortunately they are to some extent kept under by parasites and foes of their own rank. Hence one of the most important duties of an agricultural entomologist is to warn the public against destroying their allies.

The so-called red-bug of Florida and the West Indies (*Drysdereus suturellus*) is very destructive, both to the cotton and the orange crops. It may possibly be utilised as a dye, since with an alum mordant it dyes woollens and silks a rich orange-yellow.

Geological Survey of Canada. A. R. C. SELWYN, F.R.S., Director. Report of Progress for 1878-79. Montreal: Dawson Brothers.

DURING the season much useful work has been done, though a portion of it, from lack of time, partakes of the character of a preliminary reconnaissance rather than of a minute survey.

Dr. G. M. Dawson reports on the Queen Charlotte Islands, and enters largely into topographical details. It appears that at Anchor Cove an anthracite mine was opened in 1865, but was finally abandoned in 1872. Two distinct epochs of glaciation have been traced in British Columbia, the former of which was

the more intense; its disappearance was accompanied by a subsidence of the land amounting to several thousand feet.

The aborigines of these islands bear the name of Haidas. They possess remarkably fair skins as compared with other Indian tribes. They are rapidly decreasing in number, owing to the introduction of European diseases.

As an Appendix to this report we find a catalogue of the plants and the marine invertebrate animals observed by the explorers.

The next following report treats of the Churchill and Nelson Rivers, and of the region around the God's and the Island Lakes. The surveyor, Dr. R. Bell, has made extensive botanical and zoological collections.

The water of the River Assiniboine, which may possibly be used for the supply of the rising city of Winnipeg, contains much sulphate of magnesia. It is proposed to remove this objectionable ingredient by treatment with wood ashes. "In this way salubrious salt, the sulphate of potash, would be substituted." We strongly doubt whether the continued introduction of sulphate of potash into the system would not prove injurious. The author lays down the northern limits of the commoner forest trees in the country to the east of Hudson's Bay.

The insect-fauna is decidedly boreal in its character, and includes several European species, not forgetting the cosmopolitan *Cynthia Cardui*. No lamellicorn beetle is recorded.

Memoirs of the Geological Survey of India. Palæontologia Indica. Ser. X. Indian Tertiary amd Post-Tertiary Vertebrata. Vol. I., Part IV. Supplement to Orania and Ruminants. By R. LYDEKKER. Calcutta: Geological Survey Office. London: Trübner and Co.

THE author finds that the characters which induced him to separate the genera *Hemibos*, *Amphibos*, and *Peribos* are insufficient, and he consequently reunites them.

Vol. I., Part V. Siwalik and Narbada Proboscidea. By R. LYDEKKER.

THIS volume deals with the families Dinotheridæ and Elephantidæ. The former, now totally extinct, is characterised by the permanent dentition being in use at the same time, the second true molar having one ridge less than the preceding tooth. The genus *Dinotherium*, the only one of the family, makes an approach in the form of its cranium to some of the *Sirenia*,

especially *Halitherium*, but has also elephantine characters. Marsupial bones are said to have been developed. The genus is considered as a generalised form connecting the *Proboscidea* with the *Ungulata* and *Sirenia*. Three fossil Indian species have been distinguished, and are here described. In the second family, the Elephantidæ, never more than three teeth are in use at the same time, and the number of ridges is either equal to or greater than the number in the preceding tooth. The fossil species found in India, and here described, are *Mastodon falconei*, *M. pandionis*, *M. latidens*, *M. perimensis*, and *M. sivalensis*; *Stegodon Cliftii*, *S. bombifrons*, *S. insignis*, and *S. ganesa*; *Loxodon planifrons*, and *Euelephas hysudricus* and *E. namadicus*.

It thus appears that of the total of 38 known proboscideans, fossil and recent, no fewer than 16 belong to India, and 14 of these to the Siwalik period. Their extinction is ascribed by Prof. Huxley and Mr. Wallace to the Glacial epoch.

Ser. XIV. Tertiary and Upper Cretaceous Fauna of Western India. Vol. I., Part I. Sind Fossil Corals and Alcyonaria. By P. Martin Duncan, M.B., F.R.S.

In referring to previous works on the subject the author mentions that, in the great treatise of MM. d'Archiac and Haime, "Description des Animaux Fossiles du Groupe Nummulitique d'Inde," the localities are erroneously given as the Hala Mountains —a totally imaginary range. The Sind corals grow in a shallow sea, and form five very natural faunas, that of each geological series,—the cretaceous, nummulitic, upper nummulitic, oligocene, and miocene,—community of species being exceptional. The treatise consists of a description of the species which have been identified.

Vol. XV., Part II. Calcutta: Published for the Government of India.

This volume is devoted to an elaborate account of the Ramkola and Tatapani Coal-Fields, by C. L. Griesbach, F.G.S. Many of the seams are only a few inches in thickness, and afford little prospect of remunerative working. Others range up to 7, 9, and even 17 feet thick.

Vol. XVII., Part I. Calcutta: Printed for the Government of India.

This issue is an account of the geology of Western Sind, furnished by W. T. Blanford, F.R.S. The author draws attention to a primary distinction between the peninsular region of India, which has probably been land ever since the middle palæozoic

times, and the extra-peninsular regions—the Punjab, Sind, the Himalayas, and Assam—which have frequently been covered by sea. He treats in succession of the physical geography of the province, of its geological characteristics, and of its useful minerals. The latter unfortunately are far from numerous, and, save building stone and limestone, none are abundant. Coal has been found, but it is scant in quantity and poor in quality, being merely a lignite abounding in iron pyrites, and liable to spontaneous combustion.

There is an Appendix, by Mr. F. Fedden, on the distribution of the fossils in the tertiary and infra-tertiary groups of Sind.

Vol. XVII., Part II.

THIS part is an account of the Trans-Indus extension of the great Punjab Salt-Range, by Mr. A. B. Wynne, and is preceded by a prefatory notice from the pen of Mr. H. B. Medlicott, which proves—if proof were still needed—that there are occasional outbreaks of discord among the geologists of the great Indian Survey. We may perhaps be pardoned for remarking that we have not come upon anything of a similar nature in the reports of the American Survey of the Territories.

The region is characterised by the strange distortion of its rocks, which often assume the most singular colours,—green, blue, orange, and purple,—producing a fantastic scenery of which the illustrations give some idea. Gold is washed in the Indus and the Kuram, and in the former river is said to be accompanied by platinum, of which no recent evidence has been obtained.

CORRESPONDENCE.

*** The Editor does not hold himself responsible for statements of facts or opinions expressed in Correspondence, or in Articles bearing the signature of their respective authors.

"LIFE AND MIND ON THE BASIS OF MODERN MEDICINE."

"THALASSOPLEKTOS" and his friends having been allowed full scope for reply to our critique, we must now give our final opinion. Even granting, which we do not, that the scientific specialist is less happy than the country gentleman, &c., this is far from proving the position of our opponents. The child is happier in most cases than the adult, the barbarian than the civilised man, and, so far as we can judge, the ape in his native woods is happier than the vast majority of our species. But which is the higher? Mere "scientific education" is not research; and if man, when the "formative period" of his life is over and his powers are mature, is to turn his back upon Science, the progress of the world is at an end. Among individual men, just as among organic species in general, rise is effected by specialisation, and the "all-round" being, "*totus, teres atque rotundus*," is, in other words, a low generalised type. The reason why professional men do not desire their own career for their sons lies in our bad social arrangements, not in any fault of Science *per se*. Moreover, it is not difficult to find successive generations of scientists, *e.g.*, in the Darwin family.

THE EDITOR.

THE FORMATIVE POWER IN NATURE.

To the Editor of the Journal of Science.

SIR,—The arguments and illustrations employed by Mr. Billing upon this topic, in your number for February last,—though of course not new ones,—are clearly and forcibly put; nor do I see how they can be controverted, except at the sacrifice of every

principle of analogy, and indeed of common sense. It strikes me, however, that when (at p. 84) he challenges those who, like Haeckel, deride Teleology, and substitute for it Spontaneity,—as a *vera causa* of living beings, to account for the *intelligence* so conspicuous in their construction,—he might have turned the tables upon them, or (to use an equally familiar phrase) "hoisted them with their own petard." He might have demanded the meaning of this word *spontaneity*, or *spontaneous generation*. Every tyro knows that these words are derived from "sponte" (*anglicè*, by will). *Whose* will, then, is meant when they speak of spontaneity? *Will* is a function of mind, not of matter,—an active attribute of a personal entity, or living being,—or it has no meaning at all. Do they mean, then, that the *will* that generates an organism can be *its own*, *i.e.*, that it could *act* before it *existed?* Such self-generation only exhibits self-contradiction in those who assert it; and the only alternative is, that the *will* is that of *another* being, and, as the result of its exercise is the production of what did not previously exist, this is no less than an act of *creation:* and if *matter can create* the term is an absurd misnomer, and should be replaced by that of God.

Nor will philosophic atheism gain much by calling this creative power Nature, or Monism, or any other *ism*. Call the Being which produces so unique a result what they will, this is the Being we Christians worship and adore as the Maker of all things and the Moral Governor of his rational creation. M. Haeckel himself admits (vol. i., p. 341) that such an event as he calls spontaneous generation must have occurred, at any rate, in the remote past, and may have occurred at any time since. We may congratulate the learned Professor on having discovered what the vast mass of thoughtful observers of Nature have been convinced of from the earliest times.

I must confess myself to be uncertain whether I understand the author's meaning in the following sentence (p. 82). Referring to the vast epochs of geology, he says—"Each of these eras presents different stratifications and forms, which stratifications could only have arisen from a solidification of the gaseous substance which we term the ether." Presuming that it is the lumi in germs that is here alluded to, which he seems to consider as a gas more subtle than those composing our atmosphere, I would observe that this theory is a mere assumption, and that it is more probable that this universal medium is a form of matter *sui generis*, and that the Creator, having made it absolutely independent of the force (whatever it is) which we call gravity, has rendered it thereby incapable of solidification. It is quite as conceivable that He should have originated a hundred or a thousand differing forms of matter as that He should have made *one*, and then so altered it by successive modifications and condensations that it became totally different in ten thousand other forms. In reality these two conceptions are little better than a distinction without a difference.

That the medium which is not only the vehicle, but probably the very substance of light and heat, if not of electricity and magnetism also, should be an element of vast importance in all cosmical phenomena, I am quite prepared to admit and maintain; but this is a very different thing from regarding it as *the* original fundamental form of matter.—I am, &c.,

H. B.

HEREDITARY QUALITIES IN ANIMALS.

To the Editor of the Journal of Science.

Sir,—In considering the question of hereditary qualities in animals, a fact has come under my observation proving that in birds the peculiar note of a race is hereditary, and I forward it because if I mistake not one of your correspondents stated the opposite to be the case.

A very young canary was purchased, and kept many weeks in my house; it could not sing at all, only twit: after a while it made divers attempts; most of us gave it up, but finally, in a month or two, it reached the perfect song of its race: it arrived at this point by stages and time, and continual practice. No other bird was in the house. It was a very young one when obtained. This seems a most decisive proof.

Now that man is generally acknowledged to be but a "superior animal," should not the results found in animal psychicism be applicable to man's mind?—I am, &c.,

David Y. Cliff.

NOTES.

We learn that the last work of Mr. Frank Buckland, completed two days before his death, and now published by the Society for Promoting Christian Knowledge, contains certain new arguments against the doctrine of Evolution.

According to the "Medical Press and Circular" the latest phase of the agitation for the suppression of physiological research is an "Anti-Vivisection Prayer Meeting," which was recently held in Nicholson Street Hall, Edinburgh.

M. Ch. Robin, in a communication to the Academy of Sciences, shows that well-marked sexual differences exist in eels, and that there are no grounds for supposing them to be hermaphrodites.

M. Alph. Milne-Edwards ("Comptes Rendus," 1881, p. 384), in summarising the results of deep-sea dredgings in the Caribbean Sea and the Gulf of Mexico, remarks that, on comparing the abysmal with the littoral animals, we seem to have before us two distinct faunæ belonging to different epochs and climates. The animals of the shore deposits belong to higher types, whilst those of the depths have a more ancient character; some of them present plain affinities with the fossils of the secondary epoch, whilst others recal the larval state of certain recent species.

In the same journal M. Bouilland demonstrates that the cerebellum is the nervous centre which co-ordinates the movements necessary for standing and for locomotion.

M. H. Viallanes, in a memoir on the histolysis of Dipterous larvæ during their post-embryonic development ("Comptes Rendus," February, 1881), shows that the muscles are destroyed at the moment when the larva passes into the pupa condition.

M. A. Certes ("Comptes Rendus," Feb., 1881) finds that Infusoria may be coloured a pale blue by means of a weak solution of quinoleine blue or cyanine, though they continue to live for twenty-four or thirty-six hours after. Quinoleine blue is eminently the microscopic reagent for fatty matter. The notion that the living cell is impermeable to colouring reagents must be abandoned.

According to M. Ch. Brame pure hydrocyanic acid remains undecomposed in the tissues of poisoned animals for a month, and is less easily removed by distillation from the bodies of the Carnivora than from those of the Herbivora.

According to a writer in the "Magazine of Pharmacy" the physical and chemical methods for the analysis of potable waters have proved themselves inadequate. "Recourse will have to be had to the microscope, and to the culture-glasses used by physiologists in their inoculation experiments, before any really sound and valuable knowledge can be gained by the examination of waters."

The "Popular Science Monthly" very fairly sums up the late Mr. Frank Buckland as "a writer who could seize with alacrity the popular side of a scientific question, but seldom went deeper."

It is alleged, though not on unquestionable authority, that a priest in Lerida, Spain, has cautioned his parishioners that any person who allows himself to be treated homœopathically in sickness will be refused absolution, and, in case of death, Christian burial.

M. Pasteur, in a communication to the Academy of Sciences, shows that disease-germs (microbia) may be gradually deprived of their virulence by artificial cultivation under certain conditions, and, on the other hand, may be brought back to their original condition by successive culture in the bodies of certain animals. The microbion of chicken cholera, after being rendered innocuous, may become deadly again if passed through the bodies of canaries or sparrows.

M. Peyrusson ("Comptes Rendus") has used hyponitrous ether as a disinfectant with great success.

MM. Couty and De Lacerda conclude, after a long course of experiments, that the venom of *Bothrops jacaranda* is not a true poison, but a special pathogenic agent, ranking with the virus class. The fatal dose for an ape is relatively a thousand times smaller than that for a frog.

According to MM. J. Kunckel and J. Gazagnaire ("Comptes Rendus") the swellings of nerve-matter found at the base of hairs in insects and crustaceans consist of bipolar cellules, connected on the one side with the axial cylinder of the nerve-fibre, and on the other with a rod capped with a true hair or a transformed hair.

Dr. Fatio finds that the spray of dry sulphurous acid, driven into the cases, &c., is a powerful and safe agent for destroying parasites in museums.

According to the "American Naturalist" a full-grown hen possessing three legs was sold in the market at Shelbyville, Tennessee. The intestine was divided about midway into four distinct canals, which became reunited, but finally terminated in two distinct vents. It had also two livers, one on each side.

The Rev. C. W. Dod, writing in the "Journal of the Society of Arts," says:—"I may add that a heavy plant-label is not altogether without its advantages. In the year 1842, when I was a boy at Eton, one of the many jackdaws which built in the College Chapel insisted upon having her nest so arranged that she could, whilst sitting, see out of the turret loophole, which looked towards Windsor Castle. This could only be done by making the foundation on a step of the spiral staircase, 9 feet below; and a massive nest, 9 feet high, was accordingly built. I made friends with the college clerk, and watched the progress of the nest, and recollect that amongst the materials, besides there being a box of lucifer-matches, garden-pegs seemed to be in great request. Three or four years later, when I was at Cambridge, I recollect the present Professor of Botany exhibiting, at a meeting of the Ray Club, a newly-devised label for use in the Botanic Garden there. It was a very heavy metal one—the weight, he said, being found necessary to prevent the jackdaws carrying them up for their nests between the roofs of King's College Chapel."

M. Ch. Fievez ("Comptes Rendus") considers that if, of two heavenly bodies, the one presents broader and more nebulous hydrogen rays than those of the other, the former possesses the higher temperature.

According to M. G. Rolland ("Comptes Rendus") a temperature of $-4{\cdot}7°$ C. was experienced in the Sahara in the night between the 17th and 18th of January, 1880, the latitude being 35° N.

M. G. Rolland, in a paper read before the Academy of Sciences, considers it evident that the climate of North Africa, has become more arid since the Roman epoch, and that the Sahara in particular has deteriorated within traditional ages. This agrees with the remark of the Rev. Canon Tristram, that the fauna of the Sahara has a less decided desert character than that of Arabia.

Mr. F. H. Wenham, in a communication to Mr. J. Mayall, jun. ("Journ. Royal Micr. Soc., 1881, p. 121), gives, among other information, a method of setting the front lens of oil immersion objectives. The usual mode of "burnishing in" is difficult and uncertain, and to make an oil-tight fit the hard metal must bear heavily on the fragile glass, with the liability of distorting its figure. The following plan is recommended:—The cell is to be turned clear out, so that the lens would drop easily through. The cell is then heated, and a conical-pointed copper-wire, well tinned, and a fragment of rosin for a flux, is twisted round until a ring of tin is formed round the hole. The tin lining is then turned out true, to form the cell and bed for the lens, leaving the projecting ring necessary for burnishing. This operation is performed with an ivory stylet lubricated with soap. Before the

finishing touch is completed, if the face of the lens is seen to run out of truth (ascertained by the usual candle test), the soft metal will yield to a moderate degree of pressure applied to the proper side; the burnishing may then be completed without fear of the lens wabbling, and, finally, the edges neatly finished with the turning-tool. The soft tin plies so well round the glass that no leakage occurs with any kind of oil or spirit; and lenses thus mounted may be pushed out from the back of the cell for alteration or repair, without risk of fracture, as the tin is easily raised up without the application of a dangerous degree of force. The volatile oils and spirits used for immersion lenses act energetically in softening and dissolving either Canada balsam or shellac, and it will not answer to employ these substances for rendering them oil-tight. For the purpose of making a leaky joint tight Mr. Wenham has found ordinary sulphur to answer perfectly, as it is not acted upon by any cold immersion fluids that can be used; and as its melting-point is about 220° F., the heat required for its employment will not injure the coat of lacquer on brass work. In order to cement a front lens oil-tight in its cell it is sufficient to place this, with the lens fitted in position, on a hot plate, and drop a fragment of sulphur on the lens, raise the heat till the sulphur melts and flows round the edge. By capillary attraction it runs into the joint. Although melted sulphur is very fluid, yet it has a singular disinclination to attach itself or spread on a polished surface of glass; and this property prevents it creeping over the back of the lens as balsam or shellac would do, and when cold the button of sulphur may easily be picked off with a needle-point, leaving the surface of the glass clean.

Some years ago a standard screw for the fitting of objectives was determined on by the Royal Microscopical Society, and tools were issued, the result being the universal adoption of the Society's gauge. Latterly the stock has become exhausted; the Council have, however, completed arrangements for a further supply: sets, consisting of a gauge and pair of screw tools, can now be obtained on application to the Assistant-Secretary.

A writer to "Science Gossip" recommends the following contrivance for conveying moist specimens by post:—Thin gutta-percha, such as is used by surgeons, is cut to the required size. The joint is made by dipping a camel-hair brush in chloroform, drawing it along the edge, and then placing the part to be joined to it before the chloroform has evaporated. If the tubes are only three parts full, it will allow of a little pressure should it occur in transit. The cover can be made by rolling brown paper over a ruler or other suitable form, fastening with paste, as firework cases are made, allowing to dry, then cut to lengths required.